THE DENTAL PRACTITIONER

AND DENTAL RECORD

Including the Transactions of the British Society for the Study of Orthodontics, and the official reports of the British Society of Periodontology, the Glasgow Odontological Society, the Liverpool and District Odontological Society, the North Staffordshire Society of Dental Surgeons, the Odonto-chirurgical Society of Scotland, and the Dental and Medical Society for the Study of Hypnosis

Vol. XI, No. 9 May, 1961

Monthly 3s. 6d. post 5d. JOHN WRIGHT & SONS LTD. BATH ROAD, BRISTOL 4 Annually £2 2s. post free

Sole Agents: *Australia:* Robertson & Mullens Ltd., Melbourne; *Canada:* The MacMillan Co. of Canada Ltd., Toronto; *New Zealand:* N. M. Peryer Ltd., Christchurch; *Denmark:* Einar Munksgaard, Copenhagen; *Norway:* Olaf Noril, Oslo; *Sweden:* Gumperts Aktiebolag, Göteborg; *South Africa:* P. B. Mayer, Cape Town.

THE DENTAL PRACTITIONER
AND DENTAL RECORD

Vol. XI, *No.* 9 — *May*, 1961

CONTENTS

EDITORIAL NOTICES

CONTRIBUTIONS should be sent to the Editor, *The Dental Practitioner and Dental Record*, The Stonebridge Press, Bath Road, Bristol 4, or, if preferred, to any member of the Editorial Committee. Original articles are accepted on the understanding that they are contributed solely to this Journal.

Manuscript should preferably be typewritten with double spacing and wide margins, and the author should keep a copy. Articles and their illustrations become the property of *The Dental Practitioner and Dental Record*, unless authors reserve the right before publication.

Illustrations should be clearly numbered and legends should be written on a separate sheet of paper and not put on the backs of the originals. Each figure should be referred to in the text. Prints are preferred to X-ray negatives and should be on glossy paper. Lettering which is to appear on illustrations is best shown on an overlay or rough sketch. It should not be put on the original.

Tables should be typed on separate pages and each should have a caption which will explain the data without reference to the text.

References to dental literature should be recorded in the text, with the name of the author and the year of publication in parentheses. In the bibliography they should be arranged in alphabetical order in the following form, the abbreviations of periodicals being those adopted in the *World List of Scientific Periodicals* (1952), e.g.:—

SMITH, J. A. K. (1949), *Brit. dent. J.*, **86**, 271.

LEWIS, R. W. B. (1947), *The Jaws and Teeth*, 2nd ed., 471. London: Science Publishing Co.

Authors may obtain reprints of their articles if the Publishers are informed when the proofs are returned. They will be charged at the cost of production and 50 copies are suggested as a minimum.

BUSINESS COMMUNICATIONS should be sent to the Publishers, The Stonebridge Press, Bath Road, Bristol 4.

Back Numbers.—The Publishers would be glad to purchase copies in good condition of Nos. 1 and 5, Vol. I, Nos. 3 and 5, Vol. V, No. 12, Vol. VII, and No. 2, Vol. IX, of *The Dental Practitioner*.

Binding Cases.—Binding cases for Volumes I to X may be obtained from the Publishers at 5s., post free. They are supplied attractively lettered in imitation gold on a dark red ground. If desired, the Publishers will undertake the binding at an inclusive charge of 16s. 6d.

REPRINTS

Reprints can be supplied at a reduced price if authors will indicate their requirements at the time that proofs are returned. The following scale will be helpful as a guide to the cost; 50 copies are suggested as the minimum number.

PAGES	NUMBER REQUIRED							
	50	100	150	200	250	300	400	500
2	£ 1 0 0	£ 1 5 0	£ 1 10 0	£ 1 14 0	£ 1 17 0	£ 2 0 0	£ 2 5 0	£ 2 10 0
4	1 15 0	2 4 0	2 13 0	3 0 0	3 5 0	3 10 0	3 19 0	4 8 0
6	2 10 0	3 2 6	3 15 0	4 5 0	4 12 6	5 0 0	5 12 6	6 5 0
8	3 0 0	3 15 0	4 10 0	5 2 0	5 11 0	6 0 0	6 15 0	7 10 0
10	3 10 0	4 7 6	5 5 0	5 19 0	6 9 6	7 0 0	7 17 0	8 15 0
12	4 0 0	5 0 0	6 0 0	6 16 0	7 8 0	8 0 0	9 0 0	10 0 0
14	4 10 0	5 12 6	6 15 0	7 13 0	8 6 6	9 0 0	10 2 6	11 5 0
16	5 0 0	6 5 0	7 10 0	8 10 0	9 5 0	10 0 0	11 5 0	12 10 0
Printed Covers	£ 1 12 6	£ 1 17 6	£ 2 2 6	£ 2 7 6	£ 2 12 6	£ 2 17 6	£ 3 7 6	£ 3 17 6

THE DENTAL PRACTITIONER AND DENTAL RECORD

Vol. XI, No. 9 May, 1961

EDITORIAL

X-RAYS AND YOU

It was not so very long ago that the only warning given to dental students on their dental radiography course was to keep their fingers out of the mouth when taking X-rays.

Then the bomb was dropped. Warnings and controversy spread through the dental literature regarding the effects of X rays upon the health of the patients as well as on the dentist and his staff. To X-ray or not to X-ray became a serious question in the minds of the profession.

In various parts of the world committees of investigation were set up and the reports of deliberations are beginning to come through. Some of these reports still leave the dentist confused; nevertheless, several points have emerged which lead us to believe that the use of dental X rays is not, with modern equipment, as dangerous as it might have appeared.

Special care is indicated during the radiography of the young child and the expectant mother, but otherwise it would seem that the reasonable use of dental X rays on patients is not unduly harmful. With modern equipment, conforming to current safety standards and with a careful radiographic technique, dental radiography can still be considered a safe procedure.

As before, it is the dental surgeon himself who faces the most risks. Constant use of the X-ray machine can create hazards for the operator. Familiarity breeds contempt in radiography and he may well find himself standing, without responsible thought, closer and closer to the tube.

All persons in the surgery should be well clear of the diverging primary beam and at least 10 ft. away from the patient. If the surgery is small and distance cannot easily be used to ensure safety, then a lead screen must be installed. If the dentist is in doubt about his safety he should obtain and wear a monitoring film badge for a suitable period and have the dose he is receiving checked.

It is as well to have the X-ray machine itself examined periodically by the manufacturers to check that it is working satisfactorily.

Much has been written on the reduction of X-ray dosage, but the gist of it appears to be to reduce the beam diameter to the minimum necessary to cover the film, to use the fastest film which will properly record the details required, and to see that the beam is adequately filtered. These measures all help to provide the level of safety which in these days is expected, not only for the patient, but for the operator.

Three recent publications are worthy of the attention of all practising dental surgeons: the revised *Hazards to Man of Nuclear and Allied*

Radiations, by the Medical Research Council, and *The Radiological Hazards to Patients*, by the Adrian Committee, both published by the Stationery Office, and also Arthur Wuehrmann's *Radiation Protection and Dentistry*.

All of us have the welfare of our patients and staff at heart, and as a profession we must welcome the advice which has been made available to us in recent months and be sure we follow it.

AMALGAM OR GOLD?

By **J. M. MUMFORD**, M.Sc., M.S., F.D.S. R.C.S., and **H. W. FERGUSON**, F.D.S. R.C.S.
University of Liverpool

STUDENTS, and occasionally general practitioners, are sometimes confused about the indications for inserting gold rather than amalgam restorations. This paper attempts to show how this confusion may have arisen. It then considers the role of amalgam and gold in the various situations encountered in conservative dentistry. In so doing the advantages and disadvantages of using the materials are mentioned in specific cases rather than in the general terms found in standard texts.

SOURCES OF CONFUSION

The following factors may have caused the confusion to some degree:—

Learning to Make Inlays.—When dental students start to treat patients it is educationally appropriate for them to make simple gold inlays before making difficult ones. They may therefore place gold in situations where amalgam might otherwise have been appropriate. If the educational reasons for the choice are not explained, students may be confused about the indications for restoring teeth with gold inlays in spite of having been taught the advantages and disadvantages of using them.

Electrolytic Action (Galvanism).—There is a tradition to use either amalgam or gold for a patient, but not both, which is based on an older conception of electrolytic activity in the mouth. Though this conception has been modified there remains a tendency to think of a person as an "amalgam patient" or an "inlay patient". This seems undesirable, and it is considered that a better approach would be to choose the material according to the condition of the individual tooth. To adopt this approach may mean placing amalgam and gold in the same mouth, in adjacent teeth, and even in the one tooth. There is no doubt that an electromotive force is then set up, but this is so even when all the restorations are amalgam (Schriever and Diamond, 1952). When amalgam and gold are both present the electromotive force is greater, and in some cases it gives rise to an electrical current which causes pain (Mumford, 1960). However, in most cases pain does not occur, but when it does it is seldom severe and soon ceases. It is therefore considered that the possibility of pain due to galvanism should not deter the operator from choosing the most appropriate material.

Financial Considerations.—In some cases it may be necessary to use a material which is not the first choice because it is less expensive or less time consuming. Though not a clinical consideration, financial factors cannot be ignored and are constantly borne in mind in this paper.

CLASS I CAVITY

Standard Class I Cavity.—Amalgam is at its best when placed in a cavity with four walls and adequate retention. It can then be easily isolated from saliva and thoroughly condensed. Simple cavities are ideal for cohesive gold and inlays, but these are more expensive and take longer to fabricate. Placing cohesive gold fillings can be unpleasant for the patient. Furthermore, if proximal caries develops it is easier to remove amalgam than gold.

It has been suggested that gold is superior æsthetically, but this is a matter of opinion and frequently such restorations are seen only by the dentist.

Class I Cavity with Buccal or Lingual Extension.—Since there is a gap in one wall such a cavity is not ideal for amalgam, but

the gap is easily closed by a simple matrix and the cavity is then well suited to receive amalgam. It is essential to have adequate retention and depth for the extension. Otherwise such an extension might fracture under the stress of mastication.

Extensive Class I Cavity.—It is a general rule that "enamel must be supported by sound dentine", but there are cases where this rule need not be followed. One of these is the molar with an occlusal cavity in which caries has undermined all four walls leaving only a shell of enamel. In such cases the wide occlusal opening permits excavation of caries, and to remove all four walls would leave little more than the roots, necessitating a complex gold restoration. Moreover, the enamel towards the occlusal is at least partly supported by the enamel beneath it. For these reasons it is considered that amalgam may be used even though such a restoration may have a limited life.

If it is decided that the tooth should have capped cusps it is better to restore with gold rather than amalgam.

Inset Restorations.—If caries arises alongside an existing restoration it is sometimes necessary to remove the entire restoration and to start afresh. If the restoration is a large one, e.g., an M.O.D., its removal can be destructive of tooth tissue and disheartening for both patient and dentist. It is frequently better to leave the existing restoration and place another one adjacent to or partly within it. This is sometimes called a "patch", but the word sounds somewhat derogatory and the terms "inset restoration" or "inset" seem better. Any material may be used, but amalgam is considered the best.

Inset restorations should, of course, be used with discretion. As Morrant and Stephens (1960) have pointed out the advent of ultra high-speed methods has made it unnecessary to embark on "periodic amalgam patching".

CLASS II CAVITY

Standard Class II Cavity.—Since one wall of the cavity is missing it is necessary to use a matrix when packing amalgam, and the thickness of this may prevent the formation of a contact point. Amalgam is also subject to flow, so after some years a ledge may develop at the gingival margin and permit recurrent caries or cause marginal gingivitis. In these respects an inlay is better.

On the other hand, an inlay may be separated from the tooth by a line of cement which may dissolve away and permit recurrent caries, whereas amalgam is applied directly to the tooth. Even when a "catch" develops between the amalgam and the tooth, recurrent caries is less frequent than might be expected. Going, Massler, and Dute (1960) have shown that crystal violet dye and radio-active sodium iodide penetrate less along the margins of old amalgam fillings than newly placed ones. One might speculate that this is due to amalgam corrosion products which could have an anti-caries activity. If the matrix band is correctly wedged there may be sufficient separation to compensate for the thickness of the band, especially if this is of thin metal. Moreover, if caries occurs on the remaining proximal surface, it is easier to remove amalgam than gold. This is especially advantageous with younger patients who are more likely to develop such additional caries.

One should also consider that in circumstances which permit a standard Class II amalgam cavity with a small box and excellent retention, an inlay preparation would necessitate removal of additional healthy tissue.

If the financial aspect is also considered, it is evident that amalgam is a satisfactory material, if not the material of choice.

Extensive Class II Cavity.—If amalgam is used in an M.O. or D.O. cavity with extensive proximal loss of tooth tissue it is advisable to obtain additional retention by means of pits (*Fig.* 1).

One should, however, insert a gold inlay in such cases. Pits or pins may be placed or a slice made on the remaining proximal surface.

If the axial wall is long, the gingival floor tends to be narrower, therefore there is less resistance and less room for cutting retention, so that an amalgam is more likely to fail. In these cases a gold inlay may be preferred. Since it is often difficult in such cases to obtain a direct wax pattern, it is often better to adopt the indirect method.

If for any reason it is not possible to use gold, stainless steel wire may provide retention as described below.

Amalgam Restoration with Stainless Steel Retention.—When a large part of the crown has been lost it is possible to place an amalgam which derives its retention from stainless steel wire. Markley (1958) suggests that from one to eight holes may be drilled into dentine to a depth of 2 to 5 mm. so that when the wire pins are placed they will not be parallel. The wires are shaped so that their free ends lie within the subsequent restoration. They are then cemented into position and the amalgam packed around them. Markley points out that this is analogous to reinforced concrete.

Combined Class II and Class V Cavity.—If carious lesions are present both proximally and cervically in the same tooth the approach is affected by the extent and distribution of caries. When caries involves the whole cervical area it is satisfactory to prepare amalgam cavities for each lesion, and this may be done at separate appointments. The two restorations should meet each other at an angle of 90°.

In some cases, however, the extent of cervical caries is limited so that it is better to prepare a combined cavity as shown in *Fig.* 2. It is considered better to pack the cervical portion first; then place a matrix and pack the Class II cavity, taking special care where the box meets the cervical extension. It is possible that some dentists may prefer to extend (for prevention) the cervical part of the cavity as indicated by the interrupted line, but such a procedure may unduly weaken the remaining crown. Also zones such as that shaded in *Fig.* 2 should be preserved.

M.O.D. Cavity.—In this type of cavity a matrix must be applied to replace two walls. There are then two thicknesses of metal which make it difficult or impossible to restore the contact points. Also, with two masses of amalgam joined by only a relatively narrow isthmus, flow is more likely to lead to poor gingival margins. On the other hand, if a gold inlay is made, the contact points can be restored in the wax pattern or by adding solder to the inlay. Gold is therefore considered to be the material of choice, even though it may require removal of additional tooth tissue to allow withdrawal of the impression or pattern. Nevertheless, financial considerations usually necessitate using amalgam which in such cavities is still satisfactory.

M.O.D. with Capped Cusps.—It is possible to use amalgam even when all cusps need capping, but this is not easy. To obtain sufficient bulk of amalgam, considerable reduction of the cusps is necessary. This decreases the length of the axial walls at a time when retention is important. In such cases gold is undoubtedly

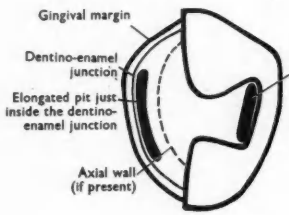


Fig. 1.

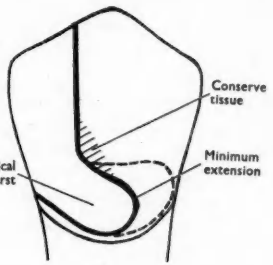


Fig. 2.

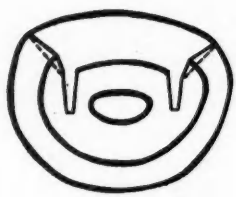


Fig. 3.

Fig. 1.—Class II amalgam cavity with extensive loss of tissue. It is advisable to obtain additional retention by means of pits as shown.

Fig. 2.—Combination of Class II and Class V cavity. Unless there is caries it is inadvisable to extend the Class V cavity to the outline shown by interrupted lines. Similarly the shaded zone should not be needlessly removed.

Fig. 3.—Class V pinlay cavity. The interrupted lines represent the walls of an amalgam cavity. Tooth tissue may therefore be conserved in these areas. Where caries is superficial the cavity may be less deep than that shown, thus conserving even more tissue.

better and it is even more advantageous if Class V restorations are present buccally or lingually.

Abutments for Partial Dentures.—When partial dentures with occlusal rests are to be made it may be necessary to insert gold inlays even if amalgam restorations would otherwise have been satisfactory. The reason for this is that when a rest-seat is cut, the remaining thickness of amalgam could be insufficient and the restoration would then fracture under the load. Where a satisfactory amalgam is already present when the partial denture is being designed it is tempting to risk cutting a rest-seat rather than replacing the amalgam with gold. If the amalgam later fractures and an inlay becomes necessary the wax pattern should be made with its occlusal part of soft casting wax. The denture is seated and the soft wax adapts to the rest more readily than does the hard wax.

Restorations for which Pulp Canal Retention is Available.—It is possible in some cases to obtain retention for amalgam by placing a screw in the pulp canal. When a considerable proportion of the crown is lost it is, however, better to use gold to make either a post inlay or a post crown.

CLASS III CAVITY

In the large majority silicate restorations are placed, but discussion of these is beyond the scope of this paper. For distal cavities in canine teeth, amalgam is generally preferred. Amalgam is also very useful for Class III cavities in the lower anterior teeth of young people.

Occasionally, a gold inlay is preferred by the patient, although preparation of an inlay necessitates removal of more sound tissue, and the polishing and cementing of Class III inlays can be a difficult and tedious operation. They are most appropriate in abutment teeth for partial dentures, especially if a rest-seat is to be cut.

Cohesive gold may be considered for small Class III cavities, especially when access is easy, as in those cases where preparation of the adjacent tooth for a crown reveals a tiny Class III cavity. Cohesive gold is also appropriate in teeth which are to be abutments for partial dentures.

CLASS IV CAVITY

In general it is necessary to use gold rather than amalgam so that there is adequate strength to withstand the forces applied during incisal movements. Occasionally, when time does not permit making an inlay, a Class IV amalgam may be placed. In this case to minimize stress the incisal corner should not be fully restored. This procedure is more appropriate with canine teeth than incisors.

CLASS V CAVITY

Standard Class V Cavity.—In cavities where retention is adequate, amalgam restorations are successful. It is necessary to guard against contamination by saliva, or even blood which might ooze from a slightly damaged gingival margin (Kantorowicz, 1960).

At the front of the mouth, gold might be preferred in some cases, but one should remember that tiny Class V inlays can be difficult to handle at all stages of their fabrication.

Extensive Class V Cavity.—Such a cavity may be extensive either occluso-gingivally or cervically.

In the first case a Tofflemire "window" matrix may facilitate packing amalgam. However, it may be better to make a Class V pinlay. This has better retention and may be more conservative of tissue, especially if caries is superficial at the periphery of the lesion (*Fig.* 3).

Where the cavity extends far around the cervical part of the tooth it may be better to prepare and fill one part at a time leaving the remainder of the carious area uncut or temporarily filled with zinc phosphate cement.

REFERENCES

GOING, R. E., MASSLER, M., and DUTE, H. L. (1960), *J. Amer. dent. Ass.*, **61**, 285.

KANTOROWICZ, G. F. (1960), *Dent. Practit.*, **10**, 158.

MARKLEY, M. R. (1958), *J. Amer. dent. Ass.*, **56**, 675.

MORRANT, G. A., and STEPHENS, R. R. (1960), *Brit. dent. J.*, **109**, 378.

MUMFORD, J. M. (1960), *Ibid.*, **108**, 299.

SCHRIEVER, W., and DIAMOND, L. E. (1952), *J. dent. Res.*, **31**, 205.

THE ROLE OF THE SOFT TISSUES IN DETERMINING NORMAL AND ABNORMAL DENTAL OCCLUSION

By **JAMES SCOTT**, M.D., D.Sc., L.D.S.
Anatomy Department, Queen's University, Belfast

INTRODUCTION

DURING the last 15 years a group of British orthodontists have advocated the thesis that the lips, cheeks, and tongue play a vital role in determining the normal form of the dental arches, and that they also act as aetiological factors in the causation of dental malocclusion. The outstanding contributions to this doctrine include papers by Rix (1946, 1953), Ballard (1951, 1953a, b, 1957), Gwynne-Evans (1951, 1956), and Hovell (1955, 1956).

It is proposed in this paper to carry out a brief critical evaluation of this important doctrine and its bearing on our knowledge of the genesis of dental malformations.

THE SOFT TISSUES AND NORMAL ARCH FORM

Ballard (1953a) wrote: "the resultant of the forces between tongue and lips and cheeks direct the dentoalveolar structures into a normal or abnormal occlusion", while Hovell stated (1955): "there is no doubt that, in normal soft tissue patterning, the crowns of the teeth are guided into position by the soft tissues on their outer and inner aspects", and in 1956: "the width of the dental arches is governed mainly by the width of the tongue".

The same kind of statement has of course been made by others, including Brodie (1957): "alveolar bone being as labile as it is, it should be apparent that the teeth would take their position around the periphery of the tongue and be held in contact with that organ by the forces of the lips and cheeks. One can say with considerable certainty that the dental arch is formed by these two forces."

The thesis that normal dental arch form is determined by the forces exerted upon the teeth by the musculature of the tongue, lips, and cheeks is at the present time orthodox teaching and is more or less universally accepted. It has, however, never been proved. Gwynne-Evans (1956) wrote: "We have correlated various dentoalveolar deformities with particular patterns of tongue and lip behaviour. A natural sequence of this correlation is the hypothesis that the teeth are alined within a state of balance between the muscle forces surrounding them. Some may ask: 'Where is the proof?' There is no proof. A hypothesis is not a conclusion, it is a starting point for observation and it should not be repudiated for want of scientific proof." This statement is of considerable interest because it admits that the hypothesis that tooth alinement is the consequence of muscle balance is only a starting point. It has, however, unfortunately become a dogma. The creators of this dogma did not of course make it up out of nothing. It is based on many years of clinical experience. It is in one sense a highly rational theory; one can readily accept its basic postulates: the plasticity of bone, the correlation between arch form and the conformation of the adjacent soft tissues, the fact that muscles, both while at rest (postural action) and when active, exert pressure; but it is in fact highly vulnerable. There are certain basic facts about which we know a lot less than we sometimes think. (1) How labile is alveolar bone? (2) What pressures are exerted by the musculature of the tongue, lips, and cheeks? (3) Are these pressures of an intensity, duration, and nature which would render them capable of acting in the manner postulated? Until we can answer these questions the hypothesis for all its attractive rationality remains in the realm of speculation.

Before the teeth ever erupt, the alveolar processes of the maxilla and mandible, containing the developing teeth within their

alveoli beneath the gum pads, have acquired a definite form. As the teeth erupt and the supporting alveolar bone grows, these structures move into the mouth cavity between the tongue on the inner side and the lips and cheeks on the outer side, but it should be remembered that the doctrine of bone plasticity must not be carried so far as to eliminate the obvious fact that bone has a definite ability to resist deforming forces as well as the forces exerted by normal muscle action. Bone is not so labile as to be completely at the mercy of the adjacent soft tissues. It has its own inherent pattern of growth, and each bone has a shape which varies somewhat from species to species. This shape and its species-variation is not merely the result of the balanced effects of the adjacent soft tissues.

A more acceptable statement of the interrelationship between the form of the dental arches and the adjacent muscles would be: as long as the pressures exerted by the lips, cheeks, or tongue are within the range of normal functional activity they have only a very limited effect (if any) on the form of the dental arches.

The form of the dental arches is the consequence of a number of developmental and functional influences including genetic factors regulating skeletal form, the ratio between tooth size and bone size, the developmental position and paths of eruption of the individual teeth, and the forces exerted by the oral and masticatory musculature. If we are to speak of a balance of forces it must include all these factors, and not merely or chiefly the forces exerted by the musculature of tongue, lips, and cheeks.

This statement is not concerned with such conditions as enlargement of the tongue, removal of the tongue, abnormal habits of the tongue and lips, thumb sucking, etc., nor is it concerned with conditions such as rickets, osteoporosis, and other abnormalities of bone growth and structure. It is based on the probability that the bone supporting the teeth is, under normal conditions, capable of withstanding the normal pressures exerted upon them during the normal processes of suckling, swallowing, speech, and mastication.

There remains the problem of the relapse of overexpanded arches, which is usually explained by an upsetting of the balance between the external and internal musculature. Winders (1958), as a result of measuring the forces exerted by the tongue, lips, and cheeks, concluded: (1) The tongue exerts a much greater force during function on the dentition than does the perioral musculature; and (2) The buccal and labial musculature does not contract during swallowing unless there is an anterior open bite, or lack of anterior overbite with accompanying anteroposterior skeletal dysplasia. Dixon (1960) found that the effect of the tongue in replacing a movable artificial tooth to the line of the arch is generally more vigorous than the effects of the cheeks.

There is, therefore, strictly speaking, no balance between the internal and external muscle forces. The tongue exerts more pressure than the cheek and lips and should therefore be able to maintain the expanded arch in its new position. But relapse after treatment is of course a reality of orthodontic practice. There are, however, other factors involved apart from the action of the oral musculature. Reitan (1959) has shown that tooth movement involves stretching of collagenous fibres both in the periodontal membrane and gum tissues, and that in young dogs, even after 232 days, some of the gingival fibres remain displaced and stretched. He writes: "relapse of the rotated tooth after retention seems to be caused primarily by a contraction of displaced gingival fibres". Thompson (1959) discusses the role of the gingival fibres in cases of relapse after treatment in the light of gingivectomy carried out in relation to teeth in monkeys which had been moved by appliances. In such cases the percentage of post-operative drift (relapse) fell from 44 per cent to 10 per cent when compared with control animals.

There is, however, one phenomenon that appears difficult to explain except by the doctrine of muscle action; that is, the natural alinement of displaced teeth, such as canines and premolars, without any further treatment once space has been made available in the dental arches. Here the clinical evidence

requires to be substantiated by experimental evidence. It should, for example, be easy to design an experiment in which cheek pressure is withheld from acting on a labially displaced canine, and observe whether in such cases the tooth remained in the displaced position.

We would conclude this section with the following statements:—

1. Individual bones have an inherent shape which shows itself early in fœtal life before any muscle forces are active. This inherent shape is reproduced even when bones are grown in tissue culture, or in other regions of the body.

2. The primary form of the alveolar processes and dental arches is determined before birth prior to the eruption of the teeth and independent of muscle activity.

3. The postnatal development of the alveolar processes and dental arches is such that arch form is maintained in spite of the greater pressure exerted by the tongue as compared with the lips and cheeks.

4. The wide variation in the form of the arches seen in comparative anatomy in such a functional phenomenon as procumbent incisors in pigs is unlikely to be explained in terms of tongue shape or the balance between the tongue and lip musculature. It should not be forgotten that the position in which teeth develop in the jaws prior to eruption plays an important role in determining their final occlusal relationship. Brown (1960) has shown that in cattle the lower incisors rotate through 90° before cutting the gum.

It would seem that the hypothesis that arch form and tooth position are determined primarily by muscle action is certainly not established to the extent postulated by some of its upholders, and that the role of the musculature requires further study before this hypothesis can be accepted even in a modified form.

THE ROLE OF ABNORMAL SOFT-TISSUE BEHAVIOUR IN THE AETIOLOGY OF MALOCCLUSION

Rix (1946) published a paper in which he stated that among 61 children with normal swallowing habits 36 per cent showed malocclusion, while among 27 children with abnormal habits 81 per cent showed malocclusion. Normal swallowing was defined as swallowing with the teeth in occlusion; abnormal swallowing with the teeth apart. He concluded that: "the shape of the jaws may very well be impressed upon them in part by their muscular environment, and I have demonstrated an important and enduring alteration in that environment".

In a later paper (1953) he describes how, in association with abnormal swallowing habits, there is established an abnormal functional relationship between the tongue tending to push the upper incisors forwards and the lower lip drawn inwards tending to move the lower incisors backwards. These abnormal muscle actions are considered to be retained characteristics of the suckling stage. A few years later Hovell (1955) classified atypical swallowing actions into three groups: (*a*) anterior tongue thrust with teeth together, (*b*) anterior tongue thrust with the teeth apart, and (*c*) tooth apart swallow with no tongue thrust. The consequences of the first is open bite without overjet of the incisors if the lips are normal (competent). If the lips are incompetent (parted at rest) the typical end result is an Angle Class II, Division 1, malocclusion. He found the second group was often associated with sucking habits, while in the third group there was a gross retroclination of both upper and lower incisor teeth. Already (1953b) Ballard had written: "It is probably correct to say that the most important factor associated with a Class II, Division 1, dento-alveolar abnormality in orthodontics in England is the abnormal swallowing action. It is my belief that it is the aetiological factor in a high percentage of cases." In the same paper he describes "another postural position of the tongue which is associated with, and almost certainly the cause of, an abnormality in lateral relationship, and that is, a high resting position in which is found a very broad maxillary arch and narrow mandibular arch with a unilateral or bilateral lingual occlusion of the mandibular buccal segments". Note in both these statements the preliminary use of the term "associated with" followed by the statement that it is his belief that the

relationship is one of cause and effect. We have again an example of accurate clinical observation being elevated into a dogma—the dogma that abnormal swallowing habits which are due to persistence of infantile suckling behaviour are the primary cause of certain forms of malocclusion including incisor open bite, Angle Class II, Divisions 1 and 2, and deformed arches.

Ardran and Kemp (1958) have studied the oral behaviour of the child in breast feeding. The lips are everted and apposed to the surface of the breast; the tongue moves forward over the lower incisor gum pad and exerts pressure against the lower surface of the teat from before backwards, pressing it against the hard palate. This is essentially the same description as that given by Gwynne-Evans in 1951. In their description of the oral behaviour during swallowing, Ardran and Kemp (1955) state that: "when swallowing begins, the tip of the tongue is thrust forwards against the upper incisor teeth and the posterior surface of the gums or the upper alveolus if there are no teeth. The tongue is then pressed upwards and forwards against the hard palate, being opposed from before backwards so that the bolus is expressed backwards. When swallowing begins, the teeth may be in apposition or slightly parted. As the tongue rests against the palate the mandible is elevated and the gap between the teeth is progressively reduced while the bolus is expressed from the mouth."

Rix (1953) asks: "Now let us suppose that at the age of, say, six years the deepening alveolar bone, carrying deciduous incisors in the process of being shed and permanent incisors on the point of eruption, is gradually moving more into a muscular field that retains characteristics of the suckling stage." He concludes that the result will be the creation of an abnormality due to the abnormal forces exerted by the tongue and lips.

Here again we must be careful: (1) To establish that the behaviour of the tongue and lips in suckling could if continued produce dental abnormalities; and (2) To distinguish between persistence of suckling patterns of tongue and lip behaviour and the establishment of habits of quite distinct nature although perhaps arising from the suckling pattern.

Suckling is a normal phenomenon. It has never been claimed that it deforms the labial segments of the alveolar bone in young children. Among many native tribes and even among European communities suckling may be continued while the deciduous incisor teeth are erupting (6–10 months). It cannot be claimed, however, that it produces any abnormalities of dental relationship in the deciduous dentition. If suckling does not normally deform the deciduous arches, why should the "persistence of the suckling behaviour pattern" deform the permanent arches, unless it has become transformed into a habit involving the abnormal use of muscle activity and the exertion of abnormal pressure on the teeth and alveolar bone?

Both in suckling and swallowing the tongue is thrust upwards and forwards against the under surface of the teat, the front of the palate, or the upper incisors. It is unlikely that this pressure is of such a nature as to produce deformity. In normal development the erupting teeth circumscribe the tongue within the developing dental arches. If the tongue does exert a pressure capable of producing open bite or protrusion of the upper incisors, it is almost certainly because the pressure exerted is more continuous and greater than in normal swallowing and is the result of the establishment of a tongue thrusting habit. Tightening of the lower lip associated with contraction of the mentalis muscle is not even remotely similar to any aspect of lip behaviour during normal suckling. It seems more likely to develop in order to establish the anterior oral seal by an alternative method, that is, by drawing the lower lip against the lingual surfaces of the protruding upper incisors. If there is a greater than normal overjet between the incisors the lower lip will tend to pass upwards between the incisors. If this becomes habitual very high pressures will be exerted which would be quite capable of exacerbating the original skeletal condition and rendering treatment difficult. It should be noted, however, that

such conditions are not necessarily merely a continuation of infantile suckling behaviour. They may be habits superimposed upon the swallowing mechanism or they may be habits developing from the suckling pattern of the oral musculature.

Furthermore, it is uncertain on what basis one can speak of swallowing with the teeth apart as being abnormal. Whether the teeth do or do not come into occlusion during swallowing may depend in some cases on the relative force exerted by the closing muscles of the jaw on the one hand and the upward thrust of the tongue against the palate on the other. During early childhood the muscles of the lips, cheeks, and tongue are sometimes relatively more powerful than the muscles of mastication (Tulley, 1953), but this need not be considered as abnormal.

An important element in the abnormal swallowing syndrome is the condition of incompetent lip posture in which the lips are open in the resting position. Authorities vary considerably in their estimates of the frequency of this condition. Gardiner (1956) found it present in 30·6 per cent among Sheffield schoolchildren between 5 and 15 years, while Walther (1960) found among East Anglian children between 11 and 13 years of age that only 18 per cent showed normal lip posture. There is some difference of opinion regarding the cause of this condition. According to Ballard (1951) it is probably genetic in origin. Hovell (1955) states that the condition is due essentially to a disproportion between the soft tissues and the bony framework, while Gwynne-Evans (1951) holds that closure of the lips at rest is the result of an acquired pattern of behaviour that becomes established as a habit at an early or a later date. On the relationship between incompetent lip posture and malocclusion, Rix (1953) writes: "One sees parted lips with well positioned incisors, with proclined and retroclined ones. Parted lips at rest are not related to any particular incisor position and do not seem to have any direct adverse moulding effect upon the incisors." It is not the resting position of the orofacial musculature that is considered important in the determining of abnormal dental arch form, but the type of activity carried out during the first phase of swallowing. It would seem that resting posture is not considered to be significant.

Ballard, however, places more emphasis on posture, and considers that both the various postures and behaviour patterns of the soft tissues are mostly inherent and inherited, and are not easy to change. He states (1953b): "Because swallowing action has to be present at birth as a mature pattern of behaviour, it is likely that the abnormal swallowing is also present at birth and probably inherited. If it was not an inherent pattern of behaviour—merely a habit—then one would have thought that it would have been much easier than our experience demonstrates for the patient to control it"; and in 1957: "soft-tissue morphology, and in particular the patterns of motor activity used for speech, expressive behaviour, and feeding, are characteristic of each individual and do not change".

Rix (1951), however, states that one is more likely to see lips apart at 4 years than at 4 weeks, and continues: "there is the defeatist attitude of those who say that the organization was genetically determined and, therefore, they could do nothing about it". Although that might be true in some cases, he felt that the situation was not hopeless, at least for a percentage of these cases.

Baril and Moyers (1960) have some significant comments on various aspects of the relationship between malocclusion and swallowing behaviour. They write: "Too many malocclusions in this sample were not associated with visceral (infantile) swallows. In fact, the mean overjet of the visceral swallowers is less than the mean of the whole sample"; and "The neuromuscular complex is not exclusively influenced by the genetic and skeletal development".

Tulley (1956) agrees with Ballard up to a point, but remarks that: "we all see remarkable changes taking place in children as they grow older", and "Emphasis has been placed on the necessity to distinguish between bad muscular habits which can be eliminated and the more innate behaviour which may resist change".

We may sum up this section with the following statements:—

1. There can be little doubt that abnormal muscle action either on the part of individual muscles or groups of muscles produces bone deformity, and especially during the period of growth. It is, however, important to differentiate abnormal action from mere variations of normal behaviour.

2. Certain forms of malocclusion, involving the anterior teeth, are closely associated with certain postural and behaviour patterns of the musculature of the tongue and lips. These behaviour patterns have been explained either as the persistence of normal suckling behaviour, especially in regard to the relationship between the tongue and lower lip, into later life and especially during the time of eruption of the permanent incisors (Rix); or as inherent and inherited abnormal patterns of behaviour which are already present at birth (Ballard); or the development of abnormal habits (Tulley); or failure of maturation (Gwynne-Evans). It is of course possible that each of these factors may operate either separately or together in different cases.

3. These factors may themselves be considered as the causes of the associated dento-alveolar abnormalities, or as contributing to and exacerbating the skeletal abnormality, or, if they are acquired habits and not inherent factors, being themselves the result of the skeletal abnormality. Leighton (1960), although he considers that his evidence supports Ballard's thesis in most cases, states that: "skeletal morphology may sometimes influence oro-muscular behaviour". It is also possible that both the soft-tissue behaviour and skeletal form could be inherited together.

We know as yet very little of the relationship between inherited factors and learning in the determination of either normal or abnormal patterns of muscular behaviour. Hindle (1955) writes: "We are only just beginning to gain any real understanding of the way in which learning processes are integrated with processes which do not involve learning to produce the adaptive behaviour seen in nature"; and Le Gros Clark (1958) states: "the harmonious co-ordination of voluntary muscles (in man) is no longer a matter of automatic and unconscious control by lower centres. It is therefore apt to be disturbed quite easily by disharmonies which have their origin in the conscious level of the mind. The formation of bad muscular habits which are expressed in faulty posture is a common cause of motor disabilities in modern man."

DISCUSSION

The main foundation for the current hypothesis regarding the role of the soft tissues in the determination of normal arch form and the aetiology of certain forms of malocclusion is based on the accurate clinical observations over a considerable period of time by highly competent observers. Fundamentally, however, no strict cause-and-effect relationship has been established. Certain skeletal and soft-tissue relationships, both normal and abnormal, exist together and develop together, but such association in itself does not establish any causal relationship. Whatever the form of the dental arches, they will be associated with closely adapted positions of the tongue, lips, and cheeks. It is, however, more likely that tongue form is determined by the arches enclosing it within the mouth cavity than that tongue form should determine the normal shape of the arches. In many cases of Angle Class II, Division 1 malocclusion, the upper lip is relatively short and flaccid, the lower lip tense and liable to ascend between the incisors during the initiation of swallowing. At the same time the tip of the tongue comes in contact with the lingual surfaces of the upper incisors above the lower incisors while the cheek teeth fail to come into contact. The associated dentoskeletal syndrome may be the result of abnormal soft-tissue behaviour; it may, however, have been the initial cause of the soft-tissue relationships. The aetiology of the fully developed condition may involve the interaction of both skeletal and soft-tissue factors, and apparently similar conditions in two individuals may be the result of different patterns of aetiological interaction.

Most clinicians first meet the child when the abnormality has already developed and know very little about the developmental history of

any individual; and it is only by the serial study of developing normal and abnormal jaws from birth through childhood that it will be possible to untangle the complex of factors acting in any individual case. Accurate clinical observation of different children seen at various ages is not enough. Observation must be correlated with classification and analysis based upon serial studies, and such serial studies themselves must be recorded by objective methods. Clinical experience, intuitions, hunches, and impressions may be valid but cannot be transmitted to and tested by others. The common tendency to postulate possible causative factors for observed clinical phenomena often results in the creation of dogmas which hold together as logical and rational constructions which can neither be proved nor disproved, but there is always the danger in such cases that anything which does not fit the dogma is overlooked or ignored. Dogma stimulates counter-dogma, and one prophet is likely to be succeeded by a successor preaching another doctrine. This is not science, but the history of orthodontics has shown too many of these pendulum-like changes of opinion. True progress can only come about by carefully designed experiments, rigorous analysis of individual cases, and a strict refusal to go beyond the evidence, even if this means admitting large gaps in our knowledge and understanding.

REFERENCES

ARDRAN, G. M., and KEMP, F. H. (1955), *Dent. Practit.*, **5**, 252.
— — — — (1958), *Brit. J. Radiol.*, **31**, 156.
BALLARD, C. F. (1951), *Trans. Europ. Orthod., Soc.*, 137.
— — (1953a), *Dent. J. Aust.*, **25**, 254.
— — (1953 b), *Trans. Europ. Orthod. Soc.*, 143.
— — (1957), *Dent. Practit.*, **8**, 42.
BARIL, C., and MOYERS, R. E. (1960), *J. dent. Res.*, **39**, 536.
BRODIE, A. G. (1957), *Trans. Europ. Orthod. Soc.*, 200.
BROWN, W. A. B. (1960), *Ibid.* (in the press).
CLARK, W. E. LE GROS (1958), *Tissues of the Body*, 4th ed. Oxford: The University Press.
DIXON, D. A. (1960), *Dent. Practit.*, **10**, 89.
GARDINER, J. H. (1956), *Ibid.*, **6**, 187.
GWYNNE-EVANS, E. (1951), *Brit. dent. J.*, **91**, 135.
— — (1956), *Dent. Practit.*, **6**, 223.
HINDLE, R. A. (1955), *Advancement of Science*, **12**, 19.
HOVELL, J. H. (1955), *Brit. dent. J.*, **98**, 114.
— — (1956), *Trans. Europ. Orthod. Soc.*, 68.
LEIGHTON, B. C. (1960), *Dent. Practit.*, **10**, 100.
REITAN, K. (1959), *Angle Orthod.*, **29**, 105.
RIX, R. E. (1946), *Dent. Rec.*, **66**, 103.
— — (1951), In discussion of paper by Gwynne-Evans.
— — (1953), *Dent. Rec.*, **73**, 427.
THOMPSON, H. E. (1959), *Amer. J. Orthod.*, **45**, 93.
TULLEY, W. J. (1953), *Dent. Rec.*, **73**, 741.
— — (1956), *Amer. J. Orthod.*, **42**, 801.
WALTHER, D. P. (1960), *Dent. Practit.*, **10**, 139.
WINDERS, R. V. (1958), *Angle Orthod.*, **28**, 226.

Clinical Eruption of the Permanent Teeth and Observations made during this Period

Because caries has been detected in fissures soon after a tooth has erupted and stagnation areas seen around erupting teeth, a study was undertaken to determine the time taken by the permanent teeth to erupt. The period of time of eruption was reckoned from the first emergence of portions of a crown of a tooth into the mouth to its attaining contact with its antagonist when the mouth is closed.

It was found in incisors that a central mamelon appeared first with gradual exposure of the whole incisal edge. Clinical eruption was completed in 9 weeks for the upper teeth and 7 weeks for the lower.

The mandibular canines occupied 16 weeks, while the maxillary ones took a little longer.

Lower premolars usually take about 11–13 weeks to erupt. In the case of the first premolar, a flap of gum often remains so closely adapted to the lingual cusp that stagnation does not take place. In the case of the upper premolars a band of tissue may be seen dividing the two cusps and this might take longer than 3 weeks to separate.

The last part of the crown to appear in the case of the first and second teeth is the disto-lingual cuspal area, and the pad of gum in this area is very often inflamed and packed beneath with debris. The flap may cover part of the tooth for as long as 8 weeks. The first and second molars take respectively 10 and 14 weeks to erupt.

It is to be noted that the anterior and premolar teeth were never covered by gum flaps for any length of time, but the eruption of the first molar may be unnoticed by either child or parent with consequent inadequate cleaning, stagnation, and caries.—HARGREAVES, A. (1960), *J. Dent. Ass. S. Afr.*, **15**, 188.

G. E. B. MOORE

TREATMENT OF THE EDENTULOUS CHILD

By **A. COCKBURN**, L.D.S. (Edin.)
Children's Department, School of Dental Surgery, University of St. Andrews
and **A. R. MacGREGOR**, F.D.S. (Edin.)
Prosthetic Department, School of Dental Surgery, University of Edinburgh

In some young children the extraction of all the deciduous teeth is necessary because of gross caries, oral sepsis, or pain. Although total extraction is relatively uncommon and must be condemned as long as a more conservative treatment is possible, it nevertheless leaves the young child without an efficient dental and oral mechanism for a number of years.

The treatment for an edentulous child of 3 or 4 years of age, which has been discussed by various writers, notably James (1953) and Krasse (1957), can be broadly divided into two stages, prosthetic and orthodontic, which overlap when the permanent teeth begin to erupt. The first stage involves the making of full dentures, which can be worn quite successfully for a number of years until the first permanent molars and incisors have erupted. These dentures, suitably modified, serve as space maintainers during the full eruption of molars and incisors, and are discarded about the age of 7 years when the second-stage treatment, viz., orthodontic, is begun.

PROSTHETIC TREATMENT

The making of dentures can be started about 4 to 6 weeks after the extraction of the deciduous teeth. In cases where the sepsis has been severe, or the extractions traumatic, this time must be extended.

Indications.—The indications for prosthetic treatment, and the benefits which the young edentulous patient will derive from it, are as follows:—

1. The usual diet of a young child contains a fairly small amount of hard fibrous food and, therefore, the loss of deciduous teeth does not greatly influence the diet, with the exception that the percentage of soft, easily masticated carbohydrate is probably increased. With full dentures, masticatory efficiency is increased and there is a return to a more balanced diet. All the young children we have fitted with full dentures appear to manage adequately with the currently popular items of diet. Parents sometimes remark on the increase in their child's weight after dentures have been fitted, but this probably takes place in spite of, rather than because of, the dentures.

2. An important aspect of treatment is the cosmetic and psychological improvement in a child after full dentures are fitted. It is not always appreciated how sensitive a child can be about appearance in relation to other children. It is interesting that children who have been fitted with full dentures become very conscious of their new appearance and, if any alterations to the dentures become necessary, e.g., rebasing, most of the children are loath to part with them, even for a short time. After the loss of teeth, the morphologic face height is reduced and the lips, especially the upper, collapse. Although both these factors take place to a lesser extent in children than adults, they nevertheless leave the child with a senile appearance, which is exaggerated by the child developing abnormal sucking movements of the lower lip (*Fig.* 1). When an edentulous child smiles or laughs, the unusual senile appearance is very noticeable and the relatively large alveolar ridges are unsightly. There is also no doubt that the clarity of speech of an edentulous child is much improved when full dentures are fitted.

3. After the loss of teeth, the child tends to oppose the jaws by thrusting forward the mandible into a postural Class III relationship. This tendency is identical to that seen in edentulous adults. It may lead to incorrect inter-arch and temporomandibular joint positions which, in turn, may lead to future malocclusion of the permanent teeth (Ungar, 1938). The fitting of full dentures helps to prevent the formation of undesirable jaw, joint, and tongue positions.

Further Considerations and Contra-indications to Prosthetic Treatment.—

1. A most important factor is the choice of patient. It is not every child who will respond favourably to the various stages of prosthetic treatment, or to the wearing of full dentures. patience and tolerance. In one's choice of patient, the child is probably less important than the parents, who, it is common to find, are very sceptical about their child wearing dentures. Full dentures will certainly not be successful if the parents are in any way

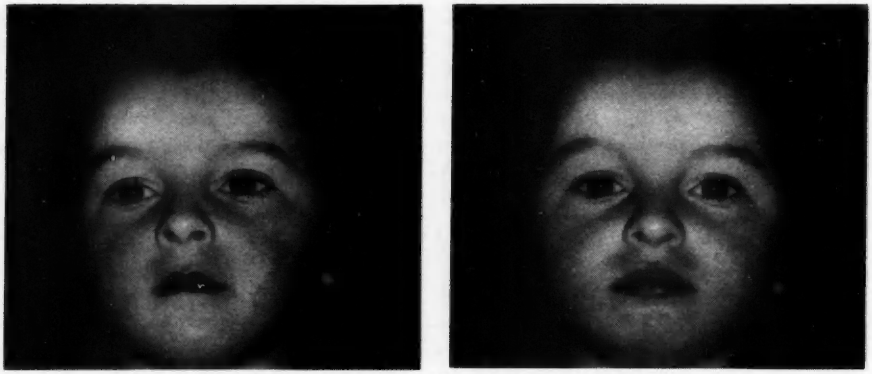
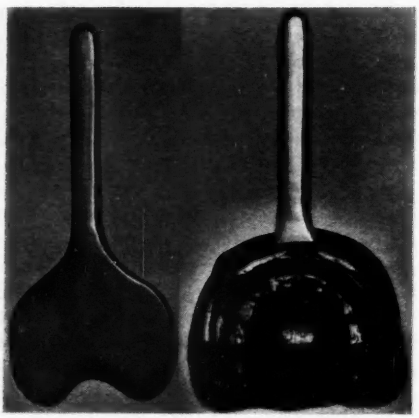


Fig. 1.—Edentulous 4½-year-old girl, without (left) and with (right) dentures.



A B

Fig. 2.—A, Perspex "lollipop" tray for simultaneous upper and lower compound preliminary impressions. B, Upper side of the impressions taken in this tray.

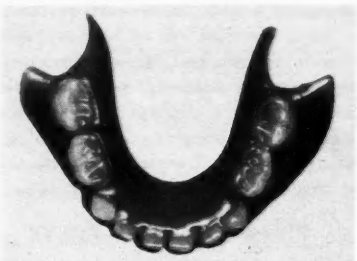


Fig. 3.—Lower denture showing "cut away" in retro-molar area.

A child who has undergone the rigours of extraction of all his or her deciduous teeth under a general anæsthetic is not inclined to be very co-operative at the time of impressions. However, as with all children who present for dental treatment, a great deal can be done by obstructive, and their full co-operation and desire for treatment is essential. The main doubt from the parent is usually whether the child will inhale or swallow one or other of the dentures. This is a most unlikely contingency, but in one child, the lower denture did slip backwards towards the throat on one occasion. It was, however, quickly recovered by the parent and the child continued to use the denture satisfactorily.

2. The presence of full dentures does not appear to affect the growth of either upper or lower jaws. Until the eruption of the permanent incisors, there is not normally

any noticeable expansion taking place (Baume, 1950; Clinch, 1951) and it would appear that the upper denture, rather than restricting this growth, is elevated from the palate by it. The periphery of the lower denture gradually impinges on the mucosa and, although this seldom causes pain, judicious adjustment is required to modify the fitting surface, and relining may be necessary.

3. There is a possibility that eruption of the permanent teeth may be delayed either by the hyperkeratinization of mucosa which takes place after dentures have been worn, or by the formation of scar tissue which occurs after extraction of deciduous teeth.

4. Various forms of oral damage may result from wearing dentures. Mild inflammation of the mucosa may occur because of simple mechanical irritation by the denture or because of lack of oral hygiene. After the permanent teeth have begun to erupt, the presence of the dentures may lead to food stagnation around the crowns and gingival margins. Caries and mild gingivitis may result from this, and strict oral hygiene must be followed. It must be remembered that, in the majority of these patients, the deciduous teeth were probably lost because of poor oral cleanliness and therefore hygiene becomes all the more important when full dentures are fitted and the permanent teeth begin to erupt.

Method.—1. Preliminary impressions are taken in impression compound, which is conveyed to the mouth in a "lollipop" tray made from coloured Perspex sheet $\frac{1}{8}$ in. thick (*Fig.* 2 A). A ball of composition is shaped around the "lollipop" and the child simply bites into this to register rough impressions of upper and lower jaws (*Fig.* 2 B). This method is quick and also has the advantage of enabling uncooperative children to handle the "lollipop" themselves.

2. For the second visit, special trays are prepared in tin or acrylic resin. Any impression material is suitable, but alginate, accelerated by using warm water, or composition, with or without an impression paste wash, are found to be best. With the restless child composition is more suitable because it is more easily and firmly placed on a "moving target" and can be re-inserted for modification should there be any peripheral inaccuracies. Because of the inaccuracy of the primary snap impression, care must be taken in checking that the special trays are not over-extended. The sulcus of an edentulous child is shallow but fairly wide, and it is essential at the impression stage to fill this sulcus completely so that the finished denture will have adequate peripheral seal.

Table I.—Average Measurements of Acrylic Teeth which are used on Full Dentures for Children

	Greatest Mesio-distal Width (mm.)	Greatest Cervico-incisal Length (mm.)
Upper Teeth		
Central	6·5	6
Lateral	5	5·5
Canine	7	6·5
First molar	7	—
Second molar	8	—
Lower Teeth		
Central	4	5
Lateral	4	5
Canine	5	6
First molar	8	—
Second molar	10	—

These measurements, based on those given by Zeisz and Nuckolls (1949) and Kramer and Ireland (1959), refer to the teeth as they appear on the finished dentures.

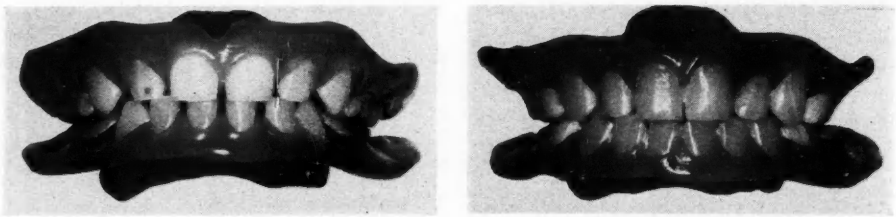
3. A bite-block, with a shellac base and a wax or composition occlusal rim, is prepared on the upper master cast. The bite is registered with this single block in the mouth by softening the occlusal rim and inducing the child to close into the position of centric occlusion. This can be done quickly and usually presents no difficulty in a child. The occlusal plane and midline are then scribed on the block while it is held in the mouth. Vertical height is not so easy to assess, as a child tends to purse the lips around the block, but the height can be checked at the trial stage of the dentures. The post-dam area should be checked at this visit.

4. The casts and block are mounted on a movable condyle articulator, a non-adjustable type being adequate, and new wax bite-blocks are made, the upper with a shellac base. In some cases there is almost no inter-alveolar clearance in the retro-molar area and the lower periphery must skirt this area (*Fig.* 3).

Acrylic teeth are selected and prepared from small mould adult stock teeth with reference to the figures shown in *Table I.*

Setting-up, especially in the molar region, is complicated by the very small inter-alveolar ridge distance. The posterior teeth should have low cusps and be narrow bucco-lingually (*Fig.* 3).

the characteristically vertical labial surface, and it is the authors' opinion that an imitation of the "spaced" type of deciduous dentition (*Fig.* 4 A) produces a better appearance. It is useful to have as a guide, when setting up, a few casts of normal deciduous dentitions, otherwise there is a definite tendency to produce "miniature adult" tooth shapes and



A B

Fig. 4.—Tooth arrangements with anterior teeth of the same size. A, A desirable arrangement in which the anteriors are spaced and waxed up typically short cervico-incisally; B, An undesirable arrangement in which the anteriors are waxed up too long and have a miniature adult appearance. The lack of spacing and dark colour accentuate this effect.

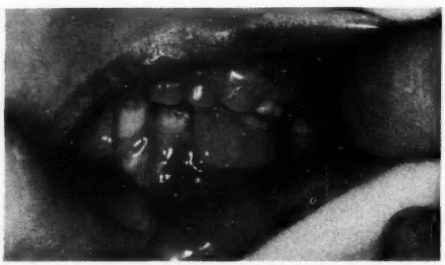


Fig. 5.—Dentures trimmed to allow eruption of $\frac{1}{1}\frac{6}{16}$. The upper incisors are too dark because they have been shaped from the tip of the original moulds (cf. the shade of the incisors in *Fig.* 4 A which were shaped from the body of the original moulds).

When shaping the anterior teeth, care should be taken not to thin them too much otherwise they will become translucent and have a bluish tinge in the mouth (*Fig.* 5). The deciduous teeth are normally whiter, less translucent, and more bulbous than the permanent teeth. The upper central incisors are broader than they are long, as are the canines whose cusps extend from the middle of the labial surface and project well below the occlusal plane until they are reduced by attrition. The upper anteriors are set-up with arrangements (*Fig.* 4 B). Grinding, to produce balanced articulation and allow unobstructed forward growth of the mandible, completes the appearance.

5. The dentures are tried in the mouth and checked for centric occlusion, vertical height, and appearance. They are finished with a mixture of acrylic appropriately shaded to simulate the pale mucosa of children.

6. When the acrylic dentures are fitted, the occlusion can be improved by spot grinding. It is sometimes found at this stage that the lower denture tends to float in the mouth. This is due to the excessive salivation and the flat shape of the denture caused by the low alveolar ridge, close bite, and shallow sulcus.

Children appear to adapt much more quickly to full dentures than do adults. One of the many reasons for this may be because of the flat shape of the dentures already mentioned. This allows easy control by the tongue and muscles of the lips and cheeks. The first few meals are occasionally difficult, but some parents have found television to be an excellent distracting agent. The dentures should not be worn at night or whenever the child is asleep.

7. The patient should be seen a few days after the dentures have been fitted and again

every 3 months. The dentures may require relining from time to time because of alveolar changes, and this is done with an impression paste wash, the taste of which most children will tolerate. Temporary relines can be carried out by using one of the silicone rubber materials. Loss of fit caused by growth and eruption of the permanent teeth is one of the biggest hazards of full dentures in children. At the beginning the fitting surface is merely ground out, but later the denture base must be cut away entirely around the erupting crowns (*Fig.* 5). As has been said, the dentures at this stage serve as space maintainers, but the fit is often poor and the lower denture base, after it has been cut around the permanent molars and incisors, becomes very weak.

ORTHODONTIC TREATMENT

On eruption of the lower lateral incisors, new upper and lower appliances are constructed to maintain present arch length until the upper lateral incisors erupt. Then it is possible, after a full radiographic examination and obtaining the necessary measurements, to assess space availability and requirements if future crowding and any accentuation of labial segment malrelation are to be avoided. A choice is then made between accepting the final loss of units in the buccal segments or regaining lost space by appliance therapy.

Acknowledgement.—Our thanks are due to Mr. D. Standen, of the Photographic Department of the Edinburgh Dental School, for the illustrations.

REFERENCES

BAUME, L. J. (1950), *J. dent. Res.*, **29**, 123.
CLINCH, L. M. (1951), *Dent. Rec.*, **71**, 61.
JAMES, P. M. C. (1953), *Dent. Practit.*, **4**, 116.
KRAMER, W. S., and IRELAND, R. L. (1959), *J. Dent. Child.*, **26**, 252.
KRASSE, M. (1957), *Odont. Revy.*, **8**, 37.
UNGAR, A. (1938), *Amer. J. Orthodont.*, **24**, 613.
ZEISZ, R. C., and NUCKOLLS, J. (1949), *Dental Anatomy*, 458. London: Kimpton.

EDITORIAL COMMITTEE DINNER

A Dinner was given on Wednesday, April 5, at Hort's Restaurant, Bristol, to members of the Editorial Committee of THE DENTAL PRACTITIONER who were visiting the city in connexion with meetings of dental societies. Also present were those members of the Publisher's staff who are closely connected with the publication of the JOURNAL.

Mr. John Wright was in the Chair and was supported by Mr. D. Derrick (Editor), Professor A. D. Hitchin, Professor F. E. Hopper, and Professor A. I. Darling. Also in the picture are Messrs. E. D. Cooke, S. F. Fish, J. K. Holt, I. R. H. Kramer, B. C. Leighton, W. D. McHugh, G. R. Seward, D. S. Shovelton, and D. F. Soul.

THE DEVELOPMENT OF THE GINGIVAL EPITHELIUM IN THE MONKEY*

By **W. D. McHUGH,**† D.D.Sc. (St. And.)
Department of Dental Surgery, University of Birmingham

EPITHELIUM is the body's first line of defence and any breach in it will expose the deeper tissues to bacteria and their toxins. If, therefore, the gingival epithelium is not firmly joined to the enamel around the neck of each tooth, there must be a line of potential weakness between the two. This might explain the very great frequency with which pathological changes are found in the gingival and periodontal tissues.

That part of the gingival epithelium which is in contact with the enamel at the neck of a tooth is widely believed to be joined organically to the enamel (Gottlieb, 1921a, b; Orban and Köhler, 1924; Kronfeld, 1930; Orban, Bhatia, Kollar, and Wenz, 1956). There is, however, an increasing amount of experimental evidence suggesting that this epithelium is not actually attached to the enamel with which it is in contact (Weski, 1922; Becks, 1929; Skillen, 1930a, b; Waerhaug, 1952; Baume, 1952, 1953).

Most of the evidence supporting the concept of an epithelial "attachment" has been obtained from histological studies of erupting and erupted teeth. Some workers claimed to have demonstrated actual "attachment" in rosin or acrylic embedded or frozen blocks of teeth and surrounding tissues (Bödecker and Applebaum, 1934; Toller, 1939, 1940; Weinreb, 1960). These relatively gross methods are, however, of doubtful value. Chance findings of epithelial cells adhering to enamel or enamel cuticles have been put forward as evidence of "attachment" between these cells and the enamel (Manley, 1936; Butcher, 1953; Macapanpan, 1954). The falseness of this assumption was beautifully demonstrated by Zander (1955) who showed that, in decalcified histological sections, enamel matrix more often remained in contact with epithelium than with dentine, although the strength of union between enamel and dentine *in vivo* is obviously much the stronger.

The present investigation was planned in an attempt to demonstrate whether or not there is an "attachment" between gingival epithelium and enamel. It seemed that the more detailed study of the development of the gingival epithelium, which is possible with modern histological techniques, might shed new light on its final relationship to the enamel.

MATERIAL AND METHODS

Human material should ideally be used for any investigation of vital processes where it is hoped to apply the results to clinical practice. For the present study, blocks of teeth and their surrounding tissues from children were required, and these proved to be extremely difficult to obtain. Also, fixation of the limited amount which was obtained proved to be very poor because of the time lapse between death and autopsy. Monkeys were therefore used for the main part of the study, as their oral and dental tissues are very similar to those of man (Schultz, 1933; Baume and Becks, 1950; Auskaps and Shaw, 1957).

Fifteen Rhesus (*Macaca mulatta*) and fifteen Cynomologous (*Macaca cynomologus*) monkeys were obtained. Their ages were estimated from the stages of development and eruption of the teeth as seen in radiographs, and according to the tables composed by Schultz (1933) they varied between 1½ and 5 years. This range covers the stages of tooth development and eruption seen in children between 5 and 18 years of age.

Each animal was anæsthetized, its vascular system irrigated first with saline and then with 10 per cent neutral buffered formalin, and the

* A paper delivered to the British Society of Periodontology in Dundee on May 21, 1960; part of a thesis presented for the degree of D.D.Sc. (St. And.) in September, 1959.

† Present address: Dental School, Park Place, Dundee, Scotland.

head removed and immersed in 10 per cent neutral buffered formalin. Subsequently, blocks of teeth and surrounding tissues were cut from the jaws, decalcified in 10 per cent formic acid, and embedded by a modification of the technique of Manley and Brain (1949). Some blocks were sectioned in the sagittal and others in the coronal plane, so that a range of sections of different teeth at different stages of eruption, cut both bucco-lingually and mesio-distally, was obtained. Representative sections from each series were stained with Harris's hæmatoxylin and eosin. Heidenhain's, van Gieson's, Mallory's, Mallory-Azan's, and Masson's staining techniques were also used in some cases.

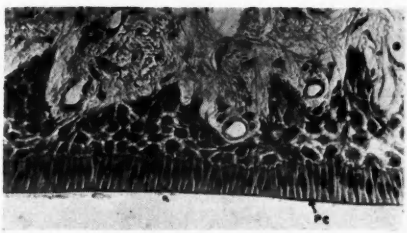


Fig. 1.—The enamel epithelium of a permanent molar of a monkey after enamel maturation. There are two layers—the reduced ameloblasts next to the primary enamel cuticle (PC), and an "outer layer" composed of squamous type cells. Van Gieson. (×205.)

RESULTS

A pattern of epithelial development common to all teeth was observed, and this will now be described. Certain modifications in this pattern were found interproximally because of the proximity of the teeth to each other, and these will be described in a subsequent paper.

The Enamel Epithelium.—Towards the end of the process of maturation of the enamel, the still unerupted tooth is covered by the reduced enamel epithelium which, at this stage, consists of only two layers, the ameloblasts and an "outer layer" (*Figs.* 1, 2). The ameloblasts are still columnar cells, but their Tomes's processes have disappeared and have been replaced by a thin homogeneous cuticle (*Fig.* 1) which appears to be the precursor of the "primary enamel cuticle". The ameloblasts are somewhat shorter and less regular than they were during the earlier stages of enamel formation and their non-pulpal ends are connected to the cells of the outer layer by numerous intercellular bridges (*Fig.* 1). The nuclei of the ameloblasts occupy a more central position than they did during amelogenesis, and a darker-staining zone of cytoplasm is often visible next to the cuticle at the pulpal ends of these cells.

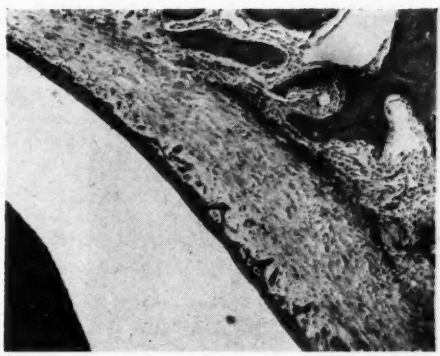


Fig. 2.—The tissues on the labial aspect of a lower permanent second incisor of a monkey a short time before the tip of the tooth reaches the oral epithelium in the course of eruption. On the labial aspect to the right, the outer border of the enamel epithelium is uneven with strands of epithelium extending into the connective tissue. In the upper part of the picture nearer the incisal edge, the "outer layer" of the enamel epithelium has become flattened and the border against the connective tissue is more even. H. and E. (×50.)

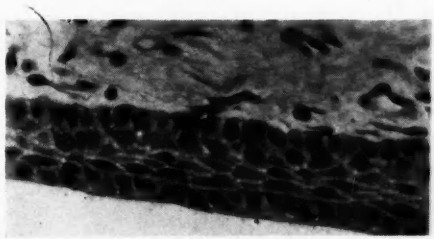


Fig. 3.—An area of ename epithelium from a lower central incisor of a 26-month-old monkey. The ameloblasts have become reduced to cuboidal cells and their nuclei are becoming pyknotic. H. and E. (×205.)

The "outer layer" of the reduced enamel epithelium is derived from three layers (the

outer enamel epithelium, the stellate reticulum, and the stratum intermedium) which were present during early amelogenesis. It is composed of irregularly polygonal cells with central nuclei and prominent intercellular bridges joining the cells to each other and to the ameloblasts (*Fig.* 1). Intercellular substance is plentiful. The outer aspect of the layer is undulating, with processes of connective tissue rich in capillaries projecting into it at irregular intervals (*Fig.* 2). This state of affairs can be seen around any tooth when enamel maturation is more or less complete and eruption has not brought the tip of the cusp or incisal edge close to the overlying oral epithelium.

As active eruption continues, however, and the crown of the tooth with its investing layers

Fig. 4.—The tissues overlying a lower lateral incisor in a 40-month-old monkey. H. and E. (×17.)

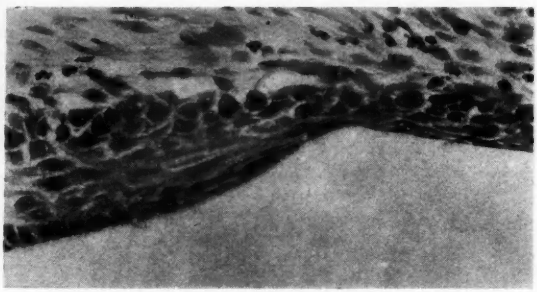


Fig. 5.—A higher magnification of the area of enamel epithelium in the box in *Fig.* 4. Numerous mitotic figures can be seen in the outer layer. H. and E. (×205.)

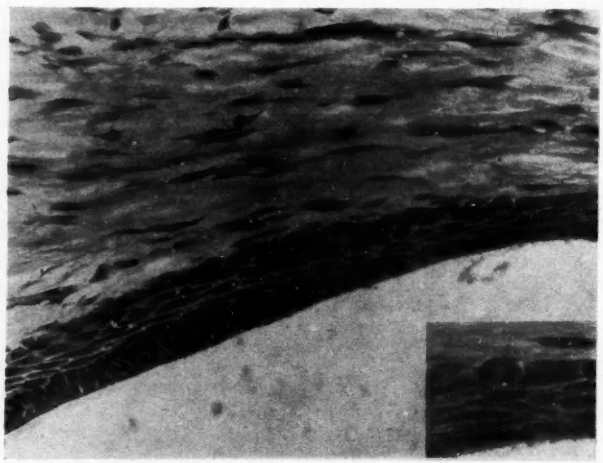


Fig. 6.—An area of enamel epithelium from over the mesiobuccal cusp of an upper left first molar in a 2-year-old monkey The tooth is at about the same stage of eruption as that in *Fig.* 4. To the left, columnar ameloblasts are still present, but nearer the tip of the cusp to the right they have become flattened and degenerate and the cells of the outer layer are starting to proliferate. On the bottom right there is a higher magnification of the area of enamel epithelium immediately above it, showing a dividing cell. H. and E. (×250.)

of enamel epithelium moves closer to the oral epithelium, further changes take place. The ameloblasts shorten until they are cuboidal in shape and the "outer layer" of the enamel epithelium becomes compressed (*Fig.* 3). These changes are seen first over the tip of the tooth and extend gradually down around the sides of the crown.

When the tip of the erupting tooth reaches a point some 200–400 microns from the overlying oral epithelium (*Fig.* 4), certain very significant changes take place in the enamel epithelium over the tips of the cusps or incisal edge. The ameloblasts become flattened and show signs of nuclear disintegration (*Figs.* 5, 6). At the same time mitotic figures appear in the cells of the "outer layer" (*Figs.* 5, 6). This is an entirely new and distinct phase in the life of the enamel epithelium as no cell division has taken place in any of its layers since before the differentiation of the ameloblasts.

Once started, this proliferation of the "outer layer" proceeds rapidly so that the total thickness of the enamel epithelium is increased, and finger-like processes of epithelium grow through the overlying highly vascular connective tissue towards the oral epithelium.

As a result of these changes, there is formed over the tip of the tooth a layer of actively proliferating epithelium with a thinner layer of degenerating ameloblasts between it and the "primary enamel cuticle". All of these are derived from the enamel epithelium.

Changes in Oral Epithelium.—At about the same time as the enamel epithelium is undergoing these changes, the overlying oral epithelium shows signs of increased activity. There is an increase in the rate of cell division in the basal layers, as evidenced by an increase in the number of mitotic figures, and processes of epithelium grow down through the underlying highly vascular connective tissue towards the erupting tooth. While the basal layers are undergoing this active proliferation, the cells nearer the surface do not undergo all the changes leading to keratin formation and a "dimple" is formed in the outer surface (*Fig.* 7).

The continued eruptive movement of the tooth soon brings the proliferating outer layers of enamel epithelium into contact with the proliferating basal layers of oral epithelium (*Fig.* 7). The epithelial strands meet and fuse to form a network between the tip of the tooth and the oral epithelium, and these strands gradually thicken until the tooth is surmounted by a solid cap of epithelium.

Gradually, the epithelial cells forming the cap become parakeratotic (*Fig.* 8) and those on the surface are desquamated into the oral cavity. Finally, the remaining epithelium comes away, like a plug (*Fig.* 8), to allow the tip of the tooth to emerge into the mouth. The enamel of the tip of the tooth is then covered only by the "primary enamel cuticle" upon which the degenerated inner enamel epithelium cells form the "secondary enamel cuticle".

Formation of the Gingival Cuff.—Epithelium now proliferates down around the tooth from the mass surrounding the erupted tip of the crown (*Figs.* 7–10). Processes of epithelium grow down and fuse to form a "cuff" which completely encircles the crown and grows gradually in an apical direction. As it does so, changes similar to those which took place earlier in the enamel epithelium over the tip of the tooth can be seen in the enamel epithelium just apical to the growing tip of the "cuff". These changes include proliferation of the formerly quiescent cells of the outer layer and degeneration of the reduced ameloblasts lying against the primary enamel cuticle (*Fig.* 11). The proliferating cells of the outer layer now fuse with the downgrowing tip of the "cuff", while the degenerating ameloblasts become compressed against the primary enamel cuticle. Thus, the quiescent reduced enamel epithelium is gradually replaced by an active gingival cuff which is separated from the primary enamel cuticle by a thin layer of degenerated cells (*Figs.* 9–11).

There is good evidence that these ameloblasts are in fact degenerating and not undergoing metaplasia to squamous epithelium or becoming keratinized. There is loss of cell outline, pyknosis or disruption of nuclei, and often infiltration of the layer by what appear

to be polymorphonuclear leucocytes (*Figs.* 11, 15). Examination in polarized light reveals very little birefringence, and histochemical methods for the demonstration of sulphydryl and disulphide groups reveal no such groups

Usually the growing cuff follows the contour of the enamel epithelium very closely (*Fig.* 9). Occasionally, however, finger-like processes extend down some little distance from the connective-tissue aspect of the cuff (*Fig.* 10).

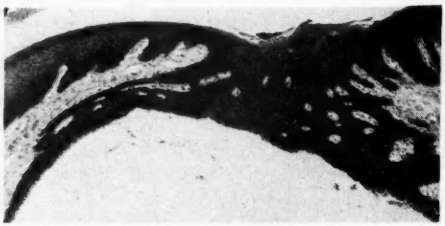


Fig. 7.—The tissues overlying a lower first permanent molar of a 2-year-old monkey. Eruption has brought the oral and enamel epithelia together and, with the proliferation of the outer layers of enamel epithelium, a solid mass of epithelium has been formed over the tip of the cusp. The degenerate remains of the inner layers of enamel epithelium lie between this mass and the enamel. H. and E. (×50.)

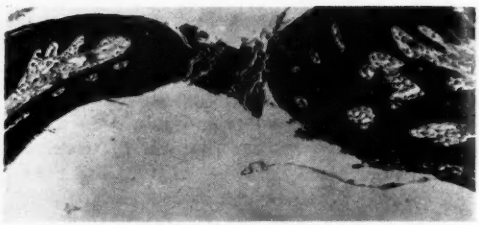


Fig. 8.—A slightly later stage than *Fig.* 7. Only a small "plug" of epithelium separates the tooth from the oral cavity. H. and E. (×40.)

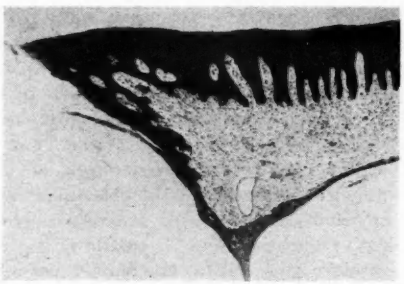


Fig. 9.—A section through the gum-tag overlying the erupting first upper molar of a 22-month-old monkey. The dark-staining proliferating cells of the oral epithelium and the cuff can readily be distinguished from the paler staining enamel epithelium in the fissure. The inner layers of enamel epithelium opposite the cuff are degenerate. H. and E. (×40.)

Fig. 10.—The tissues over the erupting cusp of a lower first molar of a 2-year-old monkey. A large process of oral epithelium can be seen growing down in the connective tissue a little distance from the proliferating outer layers of enamel epithelium. These will soon fuse to form the gingival cuff. H. and E. (×50.)

in the ameloblast layer. A detailed study of these changes is in progress.

Fig. 12 shows the distribution of mitotic figures, and the high rate of cell division towards the tip of the cuff, and in the outer cells of enamel epithelium just in advance of it, are apparent.

These changes are associated with interesting variations in the affinity of the cells for routine diachromatic stains. The reduced enamel epithelium covering the more cervical parts of the crown shows relatively little affinity for stains, both nuclei and cytoplasm appearing pale (*Fig.* 9). The basal layers of the oral

epithelium, the cells of the gingival cuff, and the cells of the active areas of enamel epithelium all stain strongly (*Fig.* 9), while the degenerating inner cells of enamel epithelium appear pale except for degenerate inflammatory cells and condensations of chromatin in pyknotic nuclei, which appear as small, darkly staining masses (*Fig.* 15).

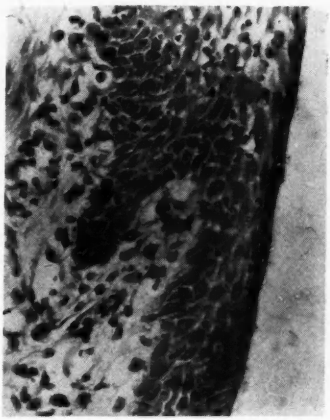


Fig. 11.—The area of junction between the gingival cuff and the enamel epithelium of a lower first molar of a 2-year-old monkey. Ameloblasts are still visible in the lower part of the picture but they have become degenerate in the upper part. Between the cuff and the primary enamel cuticle there are degenerate epithelial cells and some small darkly staining masses which may be degenerate round cells. H. and E. (×205.)

When an erupting tooth first reaches functional occlusion, the gingival cuff extends to about one-quarter of the distance from the gingival crest to the cemento-enamel junction: the remaining three-quarters is still covered by the reduced enamel epithelium which is probably in organic union with the enamel. These proportions are, however, very variable, and seem to be related to such factors as the type of tooth, the size of its crown, and the proximity of other teeth. Although a large number of sections of different types of teeth were examined, no precise pattern of development could be determined. It seemed, however, that the cuff proliferated more rapidly around anterior than around posterior teeth.

Replacement of the enamel epithelium by the cuff continues at a slower rate after the tooth has reached functional occlusion. There also seem to be greater variations in the rate of replacement between individuals and between different types of teeth. The general pattern is,

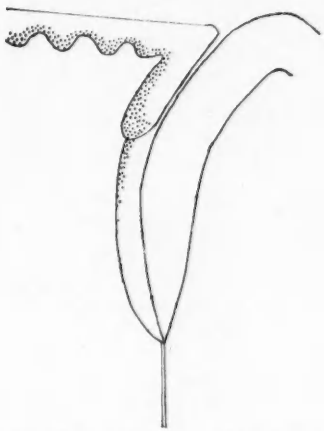


Fig. 12.—A composite diagram of the distribution of 200 mitotic figures in the oral and gingival epithelium of the monkey. Note the relatively large number of mitoses in the tip of the cuff and in the adjacent outer layers of enamel epithelium.

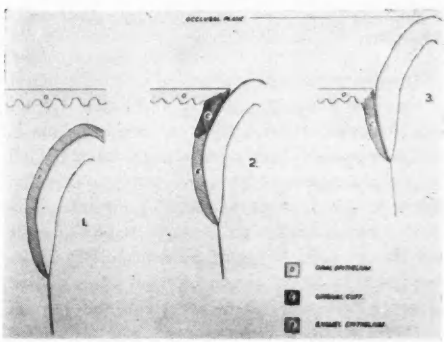


Fig. 13.—A diagram of the epithelial changes associated with tooth eruption. In (1) the crown of the tooth covered by a cap of enamel epithelium is some distance from the oral epithelium. The tip of the tooth has entered the oral cavity in (2) and a gingival cuff has formed from oral epithelium and the outer layers of enamel epithelium and is growing apically down around the crown. The inner layers of enamel epithelium degenerate as the cuff reaches them and remain as in (3) to form the secondary enamel cuticle.

however, the same as in the pre-functional phase with the enamel epithelium in advance of the growing cuff showing the typical changes: proliferation of the outer layers and degeneration of the inner.

Although major changes in the enamel epithelium are only seen close to the cuff during active eruption, both degenerative and proliferative changes can be found in the enamel epithelium some distance in advance of the cuff during the post-eruptive phase. It is thus difficult to determine which is primary—the downgrowth of the cuff, or the changes in the enamel epithelium.

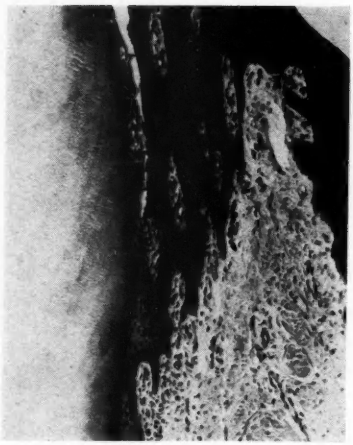


Fig. 14.—A section through a newly-erupted lower central incisor in a 3-year-old monkey. The specimen has been decalcified in a formic acid solution saturated with calcium phosphate so as to retain some of the enamel matrix. The developing gingival crevice can be seen with the cuff on one side and the degenerate remains of the inner layers of enamel epithelium forming the secondary enamel cuticle on the other. H. and E. (×100.)

Fig. 15.—The bottom of the gingival crevice on the mesial of an upper first molar in a 2-year-old monkey. On the right next to the enamel space is the primary enamel cuticle (C) with the degenerating inner layers on enamel epithelium forming the secondary cuticle on its surface. The gingival crevice is forming between these and the cells on the surface of the cuff to the left. H. and E. (×250.)

Mineralization of the cervical enamel is often incomplete until after the tip of a tooth erupts, and the enamel epithelium in these regions is still composed of columnar ameloblasts with an irregular outer layer of polygonal cells. When enamel maturation is complete, the ameloblasts become reduced to cuboidal cells and finally to a layer of flattened cells indistinguishable from those of the outer layer. In some cases the whole extent of the enamel epithelium may be reduced shortly after eruption, to a few layers of flattened cells, while in others, low columnar ameloblasts may persist in the most cervical regions until the cuff has almost reached them. Usually, the cuff can be distinguished from the enamel epithelium in two ways. First, because it is thicker (*Figs.* 7, 9, and 10) and secondly, because it stains more densely (*Fig.* 9).

From 1½ to 2 years after the eruption of the tip of a deciduous tooth into the mouth, the gingival cuff reaches its cemento-enamel junction. In permanent teeth the corresponding period is 2–4 years. Further proliferation of epithelium down along the cementum was commonly found in these older animals. It is impossible to say whether this is a physiological or pathological change, since there was always some chronic inflammatory infiltration around the gingival epithelium.

Formation of the Gingival Crevice.—Before the tip of the tooth has erupted and when the inner layers of enamel epithelium have started to degenerate, a split forms between the

gingival cuff on one side and the enamel and its cuticles on the other (*Figs.* 7, 8). This split is the precursor of the gingival crevice and is produced initially by degeneration of the ameloblast layer, causing loss of organic union between enamel and its covering epithelium.

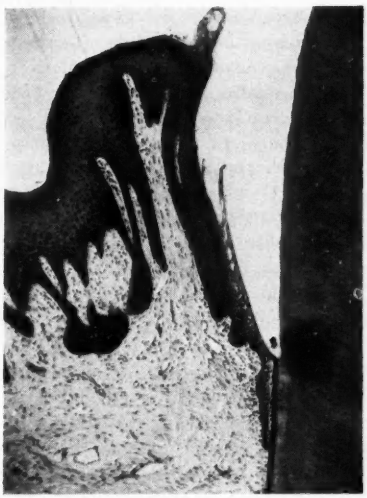


Fig. 16.—The tissues on the labial of an upper second deciduous incisor of a 2-year-old monkey. This tooth will have been erupted for about 20 months. The gingival cuff extends almost to the cemento-enamel junction and the gingival crevice extends almost three-quarters of the distance from the gingival crest to this junction. Epithelium has also proliferated some distance down over cementum. H. and E. (× 50.)

As the tooth erupts into the oral cavity by piercing the overlying epithelium and as the gingival cuff grows apically down around its crown, this degeneration of the ameloblast layer gradually extends apically (*Figs.* 9–11). A layer of degenerated cells then lies between the gingival cuff and the enamel, and these cells form what is usually termed the "secondary enamel cuticle". Since they are degenerate, a split between the cuff and the enamel cuticles can form readily, and the potential depth of the gingival crevice is thus related to the distance towards the cemento-enamel junction to which the ameloblasts have degenerated; this in turn appears to be related to the apical proliferation of the gingival cuff.

Actual crevice formation, i.e., the appearance of a space between the gingival cuff and the enamel cuticles, usually seems to lag behind the degeneration of the ameloblasts and apical proliferation of the gingival cuff (*Figs.* 9, 10, 14–16). When the cuff has proliferated to the cemento-enamel junction, the gingival crevice often extends only about three-quarters of the distance from the gingival crest to this junction (*Fig.* 16). Since, however, some evidence of inflammation was present in every specimen, it is difficult to determine whether this crevice formation was physiological, pathological, or both.

DISCUSSION

This study has revealed, during tooth eruption, a pattern of change resulting in the gradual replacement of the enamel epithelium by a gingival cuff derived mainly from the oral epithelium.

Many previous workers have described the reduction of the enamel epithelium, after enamel maturation, to two layers—short ameloblasts, and an irregular outer layer of polygonal cells (Gottlieb, 1921a, b; Orban, 1925; Neuwirth, 1925; Becks, 1929; Wilkinson, 1935; Baume, 1952).

It might be expected that the attachment which existed at an early stage between the ameloblasts and the forming enamel would persist to this stage. Good evidence of an organic union between the reduced ameloblasts, the primary enamel cuticle, and the enamel matrix has, in fact, been provided by electron microscope studies (Ussing, 1955) and by careful decalcification techniques to retain the enamel matrix (Orban, Bhatia, Kollar, and Wentz, 1956). It would thus appear that a true attachment exists between the enamel and the reduced ameloblasts.

When, however, the eruptive movements of the tooth bring the enamel epithelium close to the overlying oral epithelium, certain very significant changes take place; the outer cells of the enamel epithelium start to proliferate and the ameloblasts rapidly degenerate. Even

before the enamel epithelium and oral epithelium meet, there is loss of "attachment" between the part of the enamel epithelium over the tip of the tooth and the adjacent enamel because of this degeneration of the ameloblast layer.

The proliferating outer layers of enamel epithelium over the tip of the tooth soon meet and fuse with the oral epithelium to form a solid mass of epithelium. Processes from this mass grow down around the crown of the tooth and fuse with the proliferating outer layers of the enamel epithelium to form a cuff encircling the crown. The same changes which were apparent earlier in the enamel epithelium over the tip of the tooth can now be seen to be spreading gradually down to involve the enamel epithelium covering the rest of the crown of the tooth. The formerly quiescent outer layer of cells starts to proliferate and fuses with the downgrowing epithelial cuff, while the ameloblast layer degenerates. Thus, the enamel epithelium is gradually replaced by an epithelial cuff into which its outer layer of cells becomes incorporated. When the tip of the tooth first pierces the overlying cap of epithelium to enter the oral cavity, this cuff extends to about one-quarter of the distance from the gingival crest to the cemento-enamel junction. Since the ameloblast layer between the cuff and the enamel has degenerated, there is no organic "attachment" between them; only to the deeper parts of enamel which are still covered by reduced enamel epithelium is there a true "epithelial attachment".

A revolutionary concept of an "attachment" between the enamel of a functional tooth and the epithelium which surrounds it was formulated by Bernhard Gottlieb in 1921. He believed that, as a tooth erupts, the coronal end of its reduced enamel epithelium unites with the oral epithelium. The part of the reduced enamel epithelium apical to this line of fusion then forms the gingival epithelium which, since he believed it is in organic union with the enamel, he termed the "epithelial attachment". This theory was supported by other workers (Orban and Köhler, 1924; Skillen and Mueller, 1927; Kronfeld, 1930) and is generally accepted today.

Gottlieb and his supporters believed that all the epithelium from the gingival crest to the cemento-enamel junction of a newly-erupted tooth was derived from the reduced enamel epithelium alone. In an early paper Gottlieb (1921a) described the ameloblasts being converted to the polygonal form of the outer enamel epithelium. Later he suggested that, at the end of enamel formation, the ameloblasts, stratum intermedium, and stellate reticulum atrophy and "the outer enamel epithelium becomes as closely connected to the enamel as the ameloblasts were before" (Gottlieb, 1927). No clear explanation of how these cells of the outer enamel epithelium become attached to the enamel emerges from his writings or from those of his supporters. As, however, he believed that part of the outer enamel epithelium becomes keratinized to form a "secondary enamel cuticle" (Gottlieb, 1922) this might have been thought to provide the means of attachment.

Another theory was advanced by Becks (1929) and supported in principle by Skillen (1930a, b) and Baume (1952, 1953). They suggested that, as a tooth erupts, the enamel epithelium degenerates and is replaced by oral epithelium which grows down between it and the underlying connective tissue. Becks (1929) and Skillen (1930a, b) believed that the degenerating enamel epithelium then became keratinized to form a "cuticula dentis" which cemented epithelium to enamel.

This belief that degenerating epithelium could become keratinized and provide a means of union was based on the theory that keratinization is a result of cellular degeneration and destruction. More recent work has disproved this belief, and it has been shown that keratinization is *not* a result of degeneration but is the final stage in a process of intrinsic differentiation (Rothman, 1954). Thus, if the enamel epithelium degenerates in whole or in part, as suggested by these earlier workers and confirmed by the present study, it cannot keratinize to provide a means of attachment between epithelium and enamel.

Considerable evidence that the inner part of the reduced enamel epithelium degenerates and does not keratinize is provided by the

present investigation and by a related study, the results of which will be published shortly. The fibrous protein of keratin is birefringent (Montagna, 1956) and contains cystine and some sulphydryl groups (Rothman, 1954). No birefringence, cystine, or sulphydryl groups could be demonstrated in the inner layers of enamel epithelium opposite the cuff. There was, however, extensive karyolysis and rupture of cell membranes indicative of degeneration (*Figs.* 11, 15).

The Gingival Crevice.—Near the gingival crest, a crevice or split was regularly observed between the surface of the cuff and the degenerating inner layers of enamel epithelium. This crevice extended apically for a variable distance towards the growing tip of the cuff.

Splits in the gingival epithelium have been observed by many previous workers (Gottlieb, 1921a, b, 1922; Weski, 1922; Orban and Köhler, 1924; Becks, 1929; Skillen, 1930a, b) and have been attributed by some to trauma during life (Gottlieb, 1922—rats only; Orban and Köhler, 1924—man and "animals"). As, however, these splits regularly appear over unerupted teeth (*Figs.* 7, 8) where they cannot have been produced by direct trauma, this does not seem to be a satisfactory explanation.

On the evidence described here, it would appear that the formation of a split or crevice is due primarily to degeneration of the inner layers of enamel epithelium with consequent loss of "attachment" between enamel and epithelium. The rate and extent to which an obvious crevice develops seem to depend partly on the apical proliferation of the cuff and partly upon other factors such as the position of the gingival connective-tissue bundles and probably also upon trauma to the gingivæ during life. The cuff reaches the cemento-enamel junction in deciduous teeth 1½–2 years after eruption, and in permanent teeth 2–4 years after eruption. By then, the gingival crevice extends approximately three-quarters of the distance from the gingival crest to the cemento-enamel junction.

It seems reasonable to assume that, in regions where the inner layers of enamel epithelium have degenerated and where there is no obvious split, there is a line of weakness amounting to a *potential* split or crevice. Thus, there would be an actual or potential gingival crevice extending down around each tooth to about the level to which the gingival cuff had proliferated. The conversion of the potential crevice into an obvious macroscopic space may well be due to pathological disruption of the gingival collagen fibres, on which it is generally agreed the strength of adaptation of gingivæ to tooth primarily depends (Orban, Bhatia, Kollar, and Wentz, 1956).

It has been suggested that a gingival crevice is not found in the "ideal normal" and that its presence is evidence of pathological change (Gottlieb, 1921a; Orban and Köhler, 1924). This view cannot, however, be accepted, since crevices between enamel and epithelium were found in the present material *before* eruption. A gingival crevice appears to be a physiological split resulting from the way in which the gingival epithelium develops.

The presence of epithelial cells "adhering" to the surface of enamel has been taken as evidence that the attachment between these cells and the enamel is stronger than that between these and the other epithelial cells (Manley, 1936; Butcher, 1953; Macapanpan, 1954). Zander (1955) demonstrated the fallacy of this assumption and it is obvious from the present study that these cells "adhere" to the enamel merely because they are degenerate and have lost their attachment to anything which might dislodge them. It is these degenerate cells which form the "secondary enamel cuticle" which is rapidly lost when it is exposed to the forces of mastication.

SUMMARY

The histology of the development of the gingival epithelium was studied in 30 monkeys. The cellular changes are described and the following conclusions are drawn:—

1. Gingival epithelium develops from oral epithelium and the outer layers of the reduced enamel epithelium. Cells from these two sources form a gingival cuff which proliferates down around the crown of the tooth, replacing the reduced enamel epithelium. This process is not complete when a tooth first erupts, and

the cuff reaches the cemento-enamel junction $1\frac{1}{2}$–4 years later.

2. As the cuff proliferates apically the inner layers of enamel epithelium adjacent to it degenerate. Their remains form the "secondary enamel cuticle".

3. There is no "attachment" between the cells of the epithelial cuff and the enamel. A true "epithelial attachment" probably persists where reduced enamel epithelium is present, and is lost as this is replaced by the cuff.

4. A gingival crevice is a "normal" phenomenon and can be seen *before* eruption. Its depth is related to the distance to which the gingival cuff has proliferated towards the cemento-enamel junction.

Acknowledgements.—The invaluable technical assistance of Mr. G. A. Johnson and Mr. A. A. Cooper of The School of Dental Surgery, Birmingham, and the secretarial work of Miss J. M. Storrier, of Dundee, are gratefully acknowledged.

REFERENCES

AUSKAPS, A. M., and SHAW, J. H. (1957), *J. dent. Res.*, **36**, 432.
BAUME L. J. (1952), *J. Periodont.*, **23**, 71.
BAUME, L. J. (1953), *J. Periodont.*, **24**, 99.
— — and BECKS, H. (1950), *Amer. J. Orthodont.*, **36**, 723.
BECKS, H. (1929), *J. Amer. dent. Ass.*, **16**, 2167.
BÖDECKER, C. F., and APPLEBAUM, E. (1934), *Dent. Cosmos*, **76**, 1127.
BUTCHER, E. O. (1953), *Brit. dent. J.*, **44**, 197.
GOTTLIEB, B. (1921a), *Dtsch. Mschr. Zahnheilk.*, **34**, 142.
— — (1921b), *Z. Stomat.*, **19**, 129.
— — (1922), *Vjschr. Zahnheilk.*, **38**, 273.
— — (1927), *J. Amer. dent. Ass.*, **14**, 2178.
KRONFELD, R. (1930), *Ibid.*, **17**, 1889.
MACAPANPAN, L. C. (1954), *J. Periodont.*, **25**, 243.
MANLEY, E. B. (1936), *Brit. dent. J.*, **61**, 265.
— — and BRAIN, E. B. (1949), *Ibid.*, **86**, 1
MONTAGNA, W. (1956), *The Structure and Function of Skin*. New York: Academic Press Inc.
NEUWIRTH, F. (1925), *Z. Stomat.*, **23**, 318.
ORBAN, B. (1925), *Ibid.*, **23**, 599.
— — and KÖHLER, J. (1924), *Ibid.*, **22**, 353.
— — BHATIA, H., KOLLAR, J. A., and WENTZ, F. M. (1956), *J. Periodont.*, **27**, 167.
ROTHMAN, S. (1954), *Physiology and Biochemistry of the Skin*. Chicago: University of Chicago Press.
SCHULTZ, A. H. (1933), Chapter on "Growth and Development" in *The Anatomy of the Rhesus Monkey*, ed. C. G. Hartman and W. L. Straus. London: Baillière, Tindall & Cox.
SKILLEN, W. G. (1930a), *J. Amer. dent. Ass.*, **17**, 645.
— — (1930b), *Ibid.*, **17**, 1088.
— — and MUELLER, E. (1927), *Ibid.*, **14**, 1149.
TOLLER, J. R. (1939), *Brit. dent. J.*, **67**, 443.
— — (1940), *Northw. Univ. Bull. dent. Res.*, **11**, 12.
USSING, M. (1955), *Acta odont. scand.*, **13**, 123.
WAERHAUG, J. (1952), *Odont. Tidskr.*, Suppl. **6**, 1.
WEINREB, M. M. (1960), *J. Periodont.*, **31**, 186.
WESKI, O. (1922), *Vjschr. Zahnheilk.*, **38**, 1.
WILKINSON, F. C. (1935), *Dent. Rec.*, **55**, 105.
ZANDER, H. A. (1955), *J. Periodont.*, **26**, 138.

Mepivacaine Hydrochloride (Carbocaine): a Preliminary Clinical Study

Mepivacaine hydrochloride has great anæsthetic activity, a highly favourable therapeutic index, and a low level of tissue irritation. In a double blind study involving 200 patients, mepivacaine hydrochloride was compared with lidocaine hydrochloride. Both were used in 2 per cent solution *without* vasoconstrictor. Only two operators were involved; similar techniques were employed for the injections and equal amounts of solution injected for comparable procedures.

In block anæsthesia, the time of onset was 2 min. for mepivacaine and 3 for lidocaine. With infiltrations, the times were 1·5 and 2·8 min. respectively. In the case of those receiving mepivacaine, anæsthesia lasted longer than with lidocaine. Adequate anæsthesia was achieved in over 90 per cent of patients with mepivacaine, but in only 55 per cent with lidocaine. Both drugs were used on 12 patients, one on each side. Under these circumstances mepivacaine produced 45 min. to 1 hr. of moderate to deep anæsthesia while lidocaine produced only 20–45 min. of poor to moderate anæsthesia.

The possible value of mepivacaine for patients for whom the use of a vasoconstrictor is undesirable is discussed.—LOCK, F., and SADORE, M. (1961), *J. oral Surg.*, **19**, 16.

G. R. SEWARD

BOOK REVIEWS

ORAL PATHOLOGY. By KURT H. THOMA, D.M.D., Dr.med.dent.h.c. (Zürich), F.D.S. R.C.S. (Eng.), Hon.F.D.S. R.C.S. (Edin.), F.A.C.D., Professor of Oral Surgery, Boston University School of Medicine, Boston, Mass.; Professor of Oral Surgery, Emeritus, and Brackett Professor of Oral Pathology, Emeritus, Harvard University, Boston, Mass., etc.; and HENRY M. GOLDMAN, D.M.D., F.A.C.D., Professor of Stomatology and Chairman of the Department, Boston University School of Medicine, Boston, Mass.; Professor of Periodontology, Graduate School of Medicine, and Lecturer in Periodontology, School of Dentistry, University of Pennsylvania, Philadelphia, Pa., etc. Fifth Edition. 10×7 in. Pp. 1523, with 1704 illustrations, including 111 in colour. 1960. St. Louis: The C. V. Mosby Company. (London: Henry Kimpton.) £9 7s. 6d.

THE new fifth edition of this distinctive volume *Oral Pathology*, long recognized as a classic throughout the world, appears for the first time under the joint authorship of Kurt H. Thoma, D.M.D., and Henry M. Goldman, D.M.D. They have brought the entire contents up to date by adding the latest developments in oral diseases and associated syndromes.

The book is divided into eight parts covering the whole practice of dentistry. Part One concerns itself with the heredity of dental and developmental anomalies. Part Two gives a complete description of caries, pulp diseases, and periapical inflammation. Part Three embraces the anomalies and diseases of the important area of the head and jaws, whilst the various difficulties one meets connected with the malfunction of the temporomandibular joint occupy the whole of the fourth Part. Part Five deals with diseases of the muscles and nerves of the face and jaws which embrace the dental field.

Oral medicine occupies the whole of Part Six, which can be considered as a complete treatise on this subject. Part Seven does justice to the diseases and disorders of the salivary and mucous glands, whereas the last part deals with classification, description, and localization of the various tumours of the oral cavity.

In this volume an extra 24 coloured illustrations and 238 monochrome illustrations are added, bringing the grand total to 1704, out of which 111 illustrations are in colour. An exhaustive reference list is added to each chapter. This, no doubt, helps to make this present volume a comprehensive classic on oral pathology, the understanding of which is enhanced by the correlation of the clinical and X-ray findings with the microscopic picture of the disease.

This monumental work is strongly recommended to the clinicians and the student of dentistry, as these two renowned pathologists have interwoven their vast acumen into a coherent whole. H. M.

MODERN PRACTICE IN CROWN AND BRIDGE PROSTHODONTICS. By JOHN F. JOHNSTONE, D.D.S., F.A.C.D., Professor and Chairman, Department of Crown and Bridge and Partial Denture Prosthetics; RALPH W. PHILLIPS, A.B., M.S., F.A.C.D., Professor and Chairman, Department of Dental Materials; and ROLAND W. DYKEMA, D.D.S., Associate Professor, Crown and Bridge Prosthodontics, Indiana University School of Dentistry. 10×6½ in. Pp. 420+viii, with 385 illustrations. 1960. Philadelphia and London: W. B. Saunders Co. 84s.

THIS new text on crown and bridge work by three authors who have a considerable reputation in various fields of conservative practice is a most welcome addition to the present-day dental library. Not since the early thirties when Doxtater wrote his book *Procedures in Modern Crown and Bridge Work* has such a practical and concise volume been written.

In this book are to be found all the practical considerations of crown and bridge technique necessary in general practice—treatment planning, tooth preparation for various types of retainers, impression techniques, casting, and the construction of pontics. There are chapters dealing with soldering, the glazing of

facings, cementation of the bridge, as well as plastic and porcelain crown fabrication. There are particularly interesting chapters concerned with orthodontic positioning of mal-positioned abutment teeth, and construction of crowns for retaining removable dentures. A very good chapter has been included on bridge patterns discussing the plan of replacement of teeth in various positions in the arches.

Naturally it must be a difficult problem for authors to decide what to include and what to omit from a text, and there are several omissions from this book which might well be corrected in a future edition. There is no general discussion of the mechanical or engineering principles involved in crown and bridge construction. Further, although the authors have included a wide range of various types of abutments, they have not discussed in detail the inlay as a retainer even in the case of the fixed-movable bridge. The authors have included details using the more modern elastic impression materials.

Despite these small criticisms this is a book to be recommended to every practitioner who has a sincere wish to improve his technique in this field. It is simply written, amply illustrated, and easily understood. The authors are to be congratulated on a well worth-while and eminently necessary addition to the dental literary shelf. D. D. D.

DENTAL PRACTICE ADMINISTRATION. By Robert K. Stinaff, D.D.S., F.A.C.D., Akron, Ohio. $9\frac{3}{4} \times 6\frac{1}{2}$ in. Pp. 271, with 44 illustrations. 1960. St. Louis: The C. V. Mosby Company (London: Henry Kimpton). 56s.

Practice administration has far to go in Britain. The "holier than thou" attitude to the business side is still in high places.

We fight against dilution with obsolete weapons and complaint. Yet the immediate partial solution of increased individual capacity can be achieved by careful investment of our only stock-in-trade—time. Dr. Stinaff reminds us that a dentist with two chairs and one assistant can double his output: with an extra assistant his potential is tripled. But he also reminds us that we are perfectly entitled to have what we select. If this happens to be an inefficient gum-chewing assistant, or an underpaid sloven, that is that. His advice on engagement and training of staff is excellent, and few dentists of any age could study this book without gaining many times its cost.

The presentation is ethical and sound, taking the reader through a maze of common problems in roughly chronological order: organization, location, lay-out and equipment, personnel, office system and fees, finance, patient relationship, etc. However, it is a reference book crammed with useful information from which each will select his own "meat", and this cannot easily be extracted by casual reading at length. A capacious loose-leaf notebook or binder—perhaps 8×5 in. —should be on hand from the start and every item of possible personal value given a reference, keeping separate sheets for each heading, as the numerous linked aspects of the text will soon necessitate sub-divisions and expansion.

After pinpointing countless pitfalls which can trap the inexperienced in setting up practice, the text considers the many problems of growth and sows many seeds to assist this healthy development. It is interesting to learn that in the United States the Practice Consultant is now a recognized and presumably available expert.

The younger graduate should not be put off by the few apparently rather "go-getting" comments. The different pattern of ethics in America accounts for such items as the attention to "patient motivation" and some of the "95 ways to open your door". One of the advocated ways is "always wear a smile", and one or two of the others may also cause one. If non-American readers check that they are not likely to slip from local standards before acting on a few of the otherwise excellent practice building suggestions, they will come to little harm and reap much benefit.

Dr. Stinaff has put a great deal of time and thought into this book, and deserves our gratitude for it. The printers and publishers have joined to make it an example of the good standards and administration which it so ably expounds. S. L. D.-J.

ABSTRACTS FROM OTHER JOURNALS

The Management of Disorders of the Temporomandibular Joint

The concept and methods of treatment of temporomandibular joint disorders have changed during the past twenty-five years. At the beginning of that time such disorders were dealt with by "opening the bite", a method of treatment based on the hypothesis of Costen, who described the now well-known symptoms of Costen's syndrome. Anatomists, however, who studied the problem found that the structures described by Costen could not be reached by the condylar head, and patients suspected of suffering from Costen's syndrome were now treated by the elimination of premature tooth-contacts.

Later on a method of treatment which dealt with the joint itself was introduced by Schultz, who injected the joint with a sclerosing agent. The rationale of this treatment was that joint symptoms were due to hypermobility of the condylar head and the sclerosing agent, by creating scar tissue, would tighten loose ligaments and restore limited and more normal function. The author gives reasons why he considers that neither of these methods of treatment is rational today.

Clinical Investigation.—In view of the work of Moss, these two forms of treatment were based on the misconceptions that the fossa can be subjected to abnormal pressures and that a movement of the condylar head forward of the articular eminence is abnormal. The present investigation was begun 10 years ago and 250 patients were examined. A chief complaint of 90 per cent of them was facial or head pain aggravated by mandibular movements. Ten per cent complained of some form of joint dysfunction, from clicking to actual dislocation, and it was concluded that a simple pain-dysfunction syndrome was the problem.

The Syndrome.—It soon became evident that such syndromes were common in other parts of the body, e.g., writer's cramp, tennis elbow, and low back pain. The investigations led to the conclusions that these symptoms were painful impulses from muscles and tendons. With the use of various anæsthetics many patients were able to stretch their muscles and resume function, while in some cases exercise alone seemed to break the cycle and restore normal usage. A further study of 1500 temporomandibular joint patients rendered the mechanism clearer.

The Mechanism.—Goldensohn has pointed out that some patients under tension exhibit increased motor unit activity. It appears that the syndrome may be precipitated in patients with this kind of increased tension of the musculature, including that of the jaw. The investigation showed that patients with limitation experienced the onset of the symptoms upon opening the mouth on awakening, taking a wide bite, or after a long dental appointment, or sometimes following some minor change in proprioception inevitable with any type of restorative dentistry.

Occlusion.—Patients are sometimes made unhappy by restorative procedures and the author believes that such reactions fall within the scope of the syndrome, and they may be minimized by:—

1. Taking heed of patients who say that they adapt themselves poorly to restorative treatment.

2. Looking beyond the teeth, and observing the range and character of mandibular and condylar movements and the presence or absence of pain therein. It is considered that painful jaw muscles are not due to prolonged mastication, but to emotional tension exhibited as bruxism.

3. Modifying the outlook towards the problem of the occlusion. It should be borne in mind that the purpose of an occlusion is function for the patient and not to please the dentist. Altering of the occlusion of the teeth means a change in the message relayed to the muscles from the stretch receptors in the periodontal membrane.

Principles of Management.—An accurate diagnosis is the first essential. Organic disease

affecting the joint is relatively rare, but it does occur and must be excluded by differential diagnosis. In diagnosis the dangers are to see a disorder when one does not exist and vice versa. The symptoms of dysfunction are not difficult to recognize, but the differential diagnosis of facial pain is not easy, neither is the management, and it demands in the first place a general understanding of the physiological mechanisms concerned. Secondly, there must be an ability to resist the desire for dramatic results, and, thirdly, an understanding of the basic principle of therapy in other specialities of medicine, particularly psychiatry. All this knowledge is to be applied to the area in question.—SCHWARTZ, L. (1960), *J. Canad. Dent. Ass.*, **26**, 548.

G. E. B. MOORE

Some Principles involved in Partial Denture Design

Partial dentures are to be regarded as permanent restorations and not stepping-stones to full ones. They must be serviced and rebased as required in order to keep the framework in position and the remaining teeth in proper function. A study of the conditions in the mouth is to include study-models and a clasp surveyor. Cases presenting one or more free-end saddles require special attention, and opinion on how to deal with them is divided. Two groups of workers agree that the edentulous area should take all the load and the abutment teeth used to clasp for retention, but disagree about the use of stress-breakers. A third group advocates the widest possible distribution of occlusal stresses and uses standing teeth and edentulous areas for support.

Retention.—Adhesion helps to retain maxillary partial dentures, but most depend on some form of clasping. An important principle of clasp design is that a minimum of three points of contact must extend over more than one half of the circumference of the tooth.

The three components of a clasp are the retentive portion which engages the undercut area of the tooth, the rigid reciprocal arm, and the occlusal rest. The reciprocal arm is important and the abutment tooth should be prepared, if necessary, so that the reciprocal arm remains in contact with the tooth as long as the retentive arm is in contact, otherwise the force of this retentive arm can become an orthodontic one. A widely-used clasp is the T clasp because it covers a minimum of tooth structure and it can be used where undercuts are present. Clasps are direct retainers, and indirect retainers are used to prevent movement of saddles away from the supporting tissues and are placed as far as possible on the opposite side of the fulcrum line from the saddle. The fulcrum line is best explained as an imaginary line drawn through the occlusal rests of the two principal abutments about which the denture tends to rotate. Indirect retainers prevent this rotation, and examples of them are auxiliary occlusal rests, the continuous or Kennedy clasp, the linguo- or palato-plate, and the embrasure hook.

Connectors.—Minor connectors join clasps, etc., to the main framework and should be as inconspicuous as possible. Major connectors join the two sides of the appliance. More linguo-plates are used nowadays for lower dentures, at the expense of the continuous clasp and lingual bar. The advantages claimed are that the plate may be made thinner and so lighter, food impaction is obviated, and a smoother surface presents to the tongue; thermal stimulation to the underlying tissues is maintained and no pressure need be exerted on the mucosa if the plate is carried to the cingula of the anterior teeth. Upper connectors may be bars or plates. If bars are used the anterior one should be kept well up in the palatal arch but away from the teeth and the posterior one should be placed just anterior to the fovea palatinæ and posterior to the torus.

Denture Bases.—As large an area as possible should be covered for retention and support, especially for free-end saddles. A polished surface should be constructed so as to utilize the cheek and tongue for retention.—KERR, K. M. (1960), *J. Canad. Dent. Ass.*, **26**, 251.

G. E. B. MOORE